

**CURRICULUM
UNDERGRADUATE PROGRAMME
(B. TECH)**

DEPARTMENT OF MECHANICAL ENGINEERING



June - 2009

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DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To build a rich intellectual potential embedded with inter-disciplinary knowledge, human values and professional ethics among the youth, aspirant of becoming engineers and technologists, so that they contribute to society and create a niche for a successful career.

MISSION

To become a leading and unique institution of higher learning, offering state-of-the-art education, research and training in engineering and technology to students who are able and eager to become change agents for the industrial and economic progress of the nation. To nurture and sustain an academic ambience conducive to the development and growth committed professionals for sustainable development of the nation and to accomplish its integration into the global economy.

QUALITY POLICY

- Develop technical human resource of excellence suitable for global requirements.
- Ensure good quality academic and industrial research programmes in different areas of engineering and technology.
- Generate industry-institute synergy for shaping technical education to meet the requirement of industry.

Semester											Lecture Courses	L	T	P	Weekly Contact Hrs	Credits
I	MA-101 Mathematics-I (3 1 0) 4	PH-101 Physics (3 1 0) 4	IC/EC-101 Electrical Science (3 1 0) 4	CS-101 Computer Programming (2 0 0) 2	BT-101 Bio Sciences (3 0 0) 3	HM-101 Psychology of Human Behavior (2 0 0) 2	PH-102 Physics Lab. (0 0 2) 1	ME-101 Engineering Graphics (1 0 4) 3	IC/EC-102 Electrical Science Lab (0 0 2) 1	CS-102 Computer Programming Lab (0 0 2) 1	7	17	3	10	30	25
II	MA-102 Mathematics-II (3 1 0) 4	CH-101 Chemistry (3 1 0) 4	ME-102 Elements of Mechanical Engg (3 1 0) 4	HM-102 English Communication (3 0 0) 3	CE-101 Environmental Science & Technology (2 0 0) 2	HM-103 Introduction to Management (2 0 0) 2	IN-101 Manufacturing Processes (1 0 4) 3	ME-103 Mechanical Engineering Lab (0 0 2) 1	HM-104 English Communication Lab (0 0 2) 1	CH-102 Chemistry Lab (0 0 2) 1	7	17	3	10	30	25
III	ME-201 Strength of Materials (3 1 0) 4	ME-203 Theory of Machines (3 0 2) 4	ME-205 Machine Drawing (1 0 6) 4	ME-207 Applied Thermodynamics-I (3 1 0) 4	ME-209 Fluid Mechanics (3 1 0) 4	ME-211 Material Characterization Lab (0 0 2) 1	ME-213 Material Science and Metallurgy (3 0 0) 3				06	16	3	10	29	24
IV	MA-201 Mathematics-III (3 0 2) 4	ME-202 Applied Thermodynamics-II (3 1 0) 4	ME-204 Dynamics of Machines (3 1 0) 4	ME-206 Mechanics of Deformable Bodies (3 1 0) 4	ME-208 Production Processes (3 1 0) 4	ME-210 Production Processes Lab (0 0 2) 1					05	15	5	2	22	21
V	ME-301 Design of Machine Elements (3 0 2) 4	ME-303 Heat Transfer (3 1 0) 4	ME-305 I.C. Engines and Emission Control (3 1 0) 4	ME-307 Mechanical Measurement & Metrology (3 0 0) 3	ME-309 Mechatronics (3 0 0) 3	Open Elective-I (3 0 0) 3	ME-311 Heat Transfer Lab (0 0 2) 1	ME-313 Thermal Engineering Lab (0 0 2) 1	ME-315 Mechanical Measurement & Metrology Lab (0 0 2) 1		06	18	2	8	28	24
VI	ME-302 Fluid Machinery (3 1 0) 4	ME-304 Industrial Automation (3 0 0) 3	ME-306 Production Management (3 0 0) 3	ME-310 Industrial Automation and Mechatronics Lab (0 0 2) 1	ME-308 Fluid Machinery Lab (0 0 2) 1	Open Elective-II (3 0 0) 3	MA- Numericals Methods (3 0 2) 4	ME-3XX Elective-I (3 0 0) 3			06	18	1	6	25	22
ME-300 Industrial Practical Training (0 0 8) 4																04
VII	ME-401 Refrigeration and Air Conditioning (4 0 0) 4	ME-403 CAD/CAM (2 0 4) 4	ME-405 System design (3 0 2) 4	ME-407 Metal Cutting and Machine Tools (3 0 2) 4	ME-4XX Elective-II (3 0 0) 3	ME-409 Refrigeration and Air Conditioning Lab (0 0 2) 1	ME-411 Project (Ph-I) & Seminar (0 0 4) 2	Open Elective-III (3 0 0) 3			06	18	0	10	28	25
VIII	ME-402 Vibrations and Control (3 0 2) 4	ME-4XX Elective-III (3 0 0) 3	ME-4XX Elective-IV (3 0 0) 3	ME-4XX Elective-V (3 0 0) 3	Open Elective-IV (3 0 0) 3	ME-400 Project (Ph-II) (0 0 8) 4					05	15	0	10	18	20
															Total	190

Syllabus for B.Tech, Mechanical Engineering, 3rd to 8th semesters

ME-201

Strength of Materials

(3 1 0 4)

Simple stresses and strains: Concept of stress and strain: St. Venants principle of stress and strain diagram, Hooke's law, Young's modulus, Poisson ratio, stress at a point, stresses and strains in bars subjected to axial loading, Modulus of elasticity, stress produced in compound bars subjected to axial loading, Temperature stress and strain calculations due to applications of axial loads and variation of temperature in single and compound walls.

Compound stresses and strains: Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr's circle of stress, ellipse of stress and their applications, Two dimensional stress-strain system, principal strains and principal axis of strain, circle of strain and ellipse of strain, Relationship between elastic constants.

Bending moment and shear force diagrams: Bending moment and shear force diagrams, SF and BM definitions. BM and SF diagrams for cantilevers, simply supported and fixed beams with or without overhangs and calculation of maximum BM and SF and the point of contraflexure under Concentrated loads, Uniformity distributed loads over the whole span or part of span, combination of concentrated loads (two or three) and uniformly distributed loads, uniformly varying loads, application of moments.

Theory of bending stresses: Assumptions in the simple bending theory, derivation of formula: its application to beams of rectangular, circular and channel sections, composite/fletched beams, bending and shear stresses in composite beams. Unsymmetrical Bending, Combined bending and torsion, bending and axial loads etc.

Slope and deflection: Relationship between moment, slope and deflection, Moment area method, Macaulay's method, Use of all these methods to calculate slope and deflection for the determinant beams.

Torsion: Derivation of torsion equation and its assumptions. Applications of the equation of the hollow and solid circular shafts, torsional rigidity, combined torsion and bending of circular shafts, principal stress and maximum shear stresses under combined loading of bending and torsion, analysis of close-coiled-helical springs.

Thin cylinders and spheres: Derivation of formulae and calculations of hoop stress longitudinal stress in a cylinder, and sphere subjected to internal pressures increase in Diameter and volume.

Columns and struts: Columns under uni-axial load, Buckling of Columns, Slenderness ratio and conditions. Derivations of Euler's formula for elastic buckling load, equivalent length, Rankine Gordon's empirical formula.

Books Recommended

1. Pytel A H and Singer F L, "*Strength of Materials*", 4th Edition, Harper Collins, New Delhi (1987).
2. Beer P F and Johnston (Jr) E R, "*Mechanics of Materials*", SI Version, Tata McGraw Hill, India (2001).
3. Popov E P, "*Engineering Mechanics of Solids*", SI Version 2nd Edition, Prentice Hall of India, New Delhi (2003).
4. Timoshenko S P and Young D H, "*Elements of Strength of Materials*", 5th Edition, East West Press, New Delhi (1984).
5. Jindal U C, "*Introduction to Strength of Materials*", 3rd Edition, Galgotia Publishing Private Limited New Delhi (2001).

Basic Concepts: Kinematics of machine, Kinematic link and their different types, types of kinematic pair, kinematic chain, mechanism and inversions of four bar chain and slider crank mechanism. Degree of freedom, synthesis of linkages – number synthesis, Grashof's criterion and introduction to dimensional synthesis.

Velocity Analysis: Motion of a link, velocity of a point on a link by relative velocity method, velocities of slider crank mechanisms, rubbing velocity at a pin joint, velocity of a point on a link by instantaneous center method, properties and types of I-Center, Kennedy theorem and methods of locating I-centers in a mechanism.

Acceleration Analysis: Acceleration of a point on a link, acceleration in slider crank mechanism, Coriolis component of acceleration, Quick-return mechanism.

Cams and Follower: Types of cams and followers, cam terminology, types of motion of the follower, analysis of motion of the follower, analysis of motion of the follower for cams with specified contours.

Gears: Classification of gears, terminology used in gears, law of gearing, velocity of sliding, forms of teeth, construction and properties of an involute, construction and properties of cycloidal teeth, effect of variation of center distance on the velocity ratio of involute profile tooth gears, length of path of contact, arc of contact, number of pairs of teeth in contact, interference, minimum number of teeth, interference between rack and pinion, undercutting, terminology of helical and worm gears.

Gear Trains: Definition of simple, compound, reverted and epicyclic gear trains, velocity ratio of epicyclic gear trains.

Belt, Rope and Chain Drive: Types of belt drives, velocity ratio, law of belting, length of belt, ratio of friction tensions, power transmitted, effect of centrifugal tension on power transmission, condition for maximum power transmission, concept of slip and creep. Chain drive, chain length and angular speed ratio.

Governors: Different types of centrifugal and inertia governors: hunting, isochronism, stability, effort and power of governor, controlling force.

Note: In addition to the tutorials several studies related to mechanism, mechanism trains (Lathe, Milling Machines, Shaper), automobiles mechanisms, automobile gearbox, differential mechanisms will be performed by the students.

Characteristics of governors, cam and cam profile experiments will be demonstrated during the tutorial classes.

Evaluation Scheme: 25% weightage will be given to practical classes which will also include tutorial work.

Books Recommended

1. Bevan T, "*The Theory of Machines*", 3rd Edition CBS Publishers and Distributors (2002).
2. Shigley J E and Vicker J J, "*Theory of Machines and Mechanism*", 2nd Edition, McGraw Hill, New Delhi (1995).
3. Wilson C and Sadler J, "*Kinematics and Dynamics of Machine*", 3rd Edition, Prentice Hall (2002).
4. Ratan S S, "*Theory of Machines*", 1st Edition, Tata McGraw Hill, New Delhi (1993).
5. Rao J S and Dukkipati R V, "*Mechanism and Machine Theory*", 2nd Edition, New Age International (P) Limited, Delhi (1992).

Review of Principle of Orthographic Projections, fits and tolerances, machining symbols, sectioning and conventional representation, dimensioning, welding symbols, various types of screw threads, screw fasteners.

Assembly and Disassembly:

Coupling, Pin type, flexible coupling, and cone friction clutch.

Pipe and Pipe fittings.

Boiler Mountings: steam stop valve, feed check valve safety valve, blow off cock valve.

Bearings: Swivel bearing, thrust bearing, Plummer block.

Machine Tool Parts: Lathe tail stock, tool post.

Miscellaneous: Screw jack, drill press vice, connecting rod, eccentric.

Introduction to Computer Aided Drafting: Students may be given some drawing problems involving the application of available CAD softwares.

NOTE: First angle projection to be used. BIS codes for various applications in Machine Drawing. Drawings should contain bill of materials and illustrate the use of its tolerances and surface finish requirements. The syllabus given above indicates the broad outlines and the scope of the subject to be covered.

Based on the syllabus a number of sheets will be prepared by the students in practical classes as listed below:

- Sheet No.1 : Types of lines, Conventional Representation for materials.
- Assignment No.1 : Sectioning Practice on sketch book.
- Sheet No. 2 : Various types of machine components for sectioning.
- Assignment No.2 : Tolerances, Limits and Fits, Practice on Sketchbook.
- Assignment No.3 : Machining Symbols – Surface Texture and its importance.
- Assignment No.4 : Screw threads practice on sketchbook.
- Sheet No. 3 : Various Types of Nuts, Bolts, Studs and Setscrews & Foundation Bolts
- Assignment No. 5 : Coupling, its types and applications.
- Sheet No. 4 : Pin type flexible coupling and cone friction clutch.
- Sheet No. 5 : Assembly of various pipe joints and fittings.
- Sheet No. 6 : Assembly and part drawing of Screw Jack.
- Sheet No. 7 : Assembly of Drill press vice.
- Sheet No. 8 : Assembly and part drawing of Steam stop valve.
- Sheet No. 9 : Assembly of safety valve.
- Sheet No. 10 : Assembly of Blow of cock.
- Sheet No. 11 : Assembly and part drawing of Tail Stock.
- Sheet No. 12 : Assembly of Thrust bearing and Plummer block.

Assignment No. 6 : Sketch of Swivel bearing on the sketch book.

Sheet No. 13 : Assembly and part drawing of connecting Rod and eccentric.

Books Recommended

1. Gill P S, "*Machine Drawing*", 17th Edition, S K Kataria and Sons, New Delhi (2002).
2. Bhatt N D, "*Machine Drawing*", 26th Edition, Charotar Publishing House, Anand (1991).
3. Sidheshwar N, Kannaiah P and Sastry V V S, "*Machine Drawing*", 27th Reprint, Tata McGraw Hill, New Delhi (2003).
4. Luzadder W J, "*Fundamentals of Engineering Drawing*", PHI, New Delhi, 9th Edition (1988).
5. Bertoline G R, Wiebe E N., Miller C L, and Mohler J L, "*Technical Graphics Communication*", 2nd Edition, IRWIN McGraw Hill, New York (1997).

ME-207

Applied Thermodynamics-I

[3 1 0 4]

Fundamentals: Pure substances, Thermodynamic property relations, Properties of mixtures, Fuel and Combustion

Steam Generators: Review of steam generation process. Classification, Fire and water tube boilers, Description of Cochran, Locomotive, Lancashire Babcock and Wilcox boilers and Sterling Boiler, mountings and accessories: Economizer, super heater etc. Modern high pressure boilers, Characteristics of high pressure boilers, Advantages of forced circulation, steam accumulators, boiler performance, equivalent evaporation, boiler efficiency, Boiler Trial.

Working Cycles: Simple Rankine cycle, methods of improving efficiency: Feed water heating (Bleeding), reheat cycle, combined reheat and regenerative cycle, Ideal working fluid – Binary vapour cycle, combined power and heating cycles. Introduction to Steam Engine with brief discussion.

Nozzle: Types of nozzles and their utility, Flow of steam through nozzles, Critical pressure and discharge, Area of throat and exit for maximum discharge, Effect of friction on Nozzle efficiency, Supersaturated flow.

Steam Turbines : Classification; Impulse & Reaction Steam turbines, description of components , Pressure and velocity compounding, Velocity diagram and work done, Effect of blade friction on velocity diagram, Stage efficiency and overall efficiency, Reheat factor and condition curve. Degree of reaction, blade efficiency and its derivation; calculation of blade height, backpressure and extraction turbines and cogeneration; Economic assessment.

Method of attachment of blades to turbine rotor, losses in steam turbines, Governing of steam turbines, Labyrinth packing.

Condensers: Function, Elements of condensing plant, types of condensers, Dalton's law of partial pressure applied to condenser problems, condenser and vacuum efficiencies. Cooling water calculations. Effect of air leakage, Methods to check and prevent air infiltration. Description of air pump and calculation of its capacity.

Reciprocating Air Compressors: Use of compressed air in industry. Classification of air compressors, Operation of single stage reciprocating compressors, Work input and the best value of index of compression. Isothermal and polytropic efficiency. Effect of clearance and volumetric efficiency, Multistage compression and its advantages. Optimal multistaging, work input in multistage compression, Reciprocating air motors.

Books Recommended

1. Rogers and Mayhew, "*Engineering Thermodynamics*", Pearson Education New Delhi (1980).
2. Keartan W J, "*Steam Turbine Theory*", ELBS Series, London (1958).
3. Joel R, "*Basic Engineering Thermodynamics*", Addison Wesley Longman, New Delhi (1999).
4. Kostyuk A and Fralov V, "*Steam and Gas Turbines*", Mir Publishers, Moscow (1988).
5. Lee J F, "*Theory and Design of Steam and Gas Turbines*", McGraw Hill, New York (1954).

ME-209

Fluid Mechanics

[3 1 0 4]

Dimensional Analysis and Similarity: Dimension, Units, dimension reasoning, dimensional quantities, construction of relationship by dimensional analysis using the indicial methods, dimensional analysis by group methods, significant of dimensionless numbers, Geometric similarity, Dynamic similarity, similarity applied to rotodynamic machines.

Two-dimensional ideal flow: Stream function and velocity potential functions for standard flow patterns uniform flow, source, sink, doublet and free vortex; combination of uniform flow with certain flows to obtain flow patterns of various shapes such as flow past a half body, a cylinder, Rankine oval body, and a cylinder with circulation: Kutta-Joukowski Theorem-lift on a cylinder.

Viscous Flow: Navier-Stokes equation of motion, relationship between shear stress and pressure gradient, two-dimensional laminar flow between two fixed parallel planes and pipe flow, plain Couette flow and its application to hydro-dynamic theory of lubrication.

Turbulence and Turbulent through pipes: Growth of instability and transition from laminar to turbulent flow, fluctuation velocity components, intensity and scale of turbulence, Reynolds equations and turbulence modeling. Flow losses in pipes, Darcy equation for head loss due to friction.

Boundary Layer: Salient features of flow pattern in a boundary layer, Velocity and shear stress distribution along the boundary, Von-Karman momentum integral equation, quantitative correlations for boundary layer thickness, local skin friction coefficient and drag coefficient in laminar, turbulent and laminar turbulent combined boundary layer flows on a flat plate without pressure gradient, flow over a curved surface boundary layer separation and its control.

Flow Around Immersed Bodies: Concept of friction, pressure, wave and induced drag- lift and drag coefficients; variation of drag coefficient with Reynolds number for two dimensional bodies (flat plate, circular cylinder); Vortex shedding from cylindrical bodies, effect of streamlining; drag coefficient versus Reynolds number for flow past axisymmetric bodies (sphere); Terminal velocity, lift of an airfoil, airfoil of finite length-effect on drag and lift, downwash and induced drag.

Books Recommended

1. Douglas J F, Gasionckw, and Swaffield J P, "*Fluid Mechanics*", 3rd Edition Addison Wesley Longman, Inc Pitman (1999).
2. Pao H F Richard, "*Fluid Mechanics*", John Wiley and Sons (1995).
3. Kumar D S, "*Fluid Mechanics and Fluid Power Engineering*", 6th Edition SK Kataria and Sons, Delhi (1998).
4. Fay J A, "*Introduction to Fluid Mechanics*", Prentice Hall of India Private Limited, New Delhi (1996).
5. Bansal R K, "*A text book of Fluid mechanics and Hydraulic Machines*", 8th Edition, Laxmi Publications (P) Ltd. New Delhi (2002).

6. Yunus Cengel & John Cimbala, "Fluid Mechanics: Fundamentals and Applications", 2nd reprint 2007, Tata McGraw Hill, New Delhi.
7. F M White, "Fluid Mechanics", 6th ed., McGraw Hill, New York.

ME-211

Material Characterization Laboratory

[0 0 2 1]

1. Determination of Young's modulus, tensile, strength and percentage elongation for steel, aluminum, brass and cast iron specimens on universal testing machine. Also plot the stress strain diagram.
2. To perform the compression test for cast iron specimen on universal testing machine.
3. To determine the deflection for mild steel specimen and verify the beam formula for specimen in bending.
4. To determine the stiffness of the following:
 - (i) Cantilever beam (ii) Spring under compressive and tensile loading.
5. To measure the total energy absorbed in fracturing of the ductile specimen on Charpy and Izod setup, Cryogenic temperature testing and demonstration of Ductile to Brittle Transition temperature.
6. To plot and study the S-N curve for steel, aluminum and fibre reinforced composite material at 25%, 50%, 60% and 75% of ultimate tensile strength of the specimen.
7. Preparation of specimen for hardness test & testing of prepared specimens for Brinell hardness, Rockwell hardness & Vickers Hardness.
8. To study the behaviour of steel and aluminum specimen under torsion.
9. Analyzing the microstructure of steel and cast iron using Metallurgical Microscope.
10. Determining the grain size of the given specimen using Metallurgical Microscope.
11. Hardening of ferrous specimen by quenching in oil bath & Analyzing the microstructure using Metallurgical Microscope
12. Annealing of ferrous specimen by slow cooling in the furnace & Analyzing the microstructure using Metallurgical Microscope

ME-213

Material Science and Metallurgy

[3 0 0 3]

Structure of Crystalline Solids: Crystal structure and crystal systems, Closed packing, some prominent crystal structures, Miller indices, Determination of crystal structure, Reciprocal lattice.

Imperfections In Solid: Point imperfections and their equilibrium concentration, Edge and screw dislocations, Burgers vector and the dislocation loop, Stress field and energy of dislocation, Dislocation multiplication.

Strengthening Mechanisms: Grain Boundaries and deformation, strengthening from grain boundaries, Yield Point Phenomenon, Strain Ageing, Solid Solution strengthening, Strengthening from fine particles, fiber strengthening, strengthening due to point defects, Martensite strengthening etc.

Fracture: Types of Fracture, Griffith Theory, Metallographic aspects of fracture, Fractography, Ductile Fracture, Notch Effects, Ductile to Brittle Transition.

Mechanical Testing: Tension test, Hardness tests, Torsion test, Impact Test, Creep & Fatigue Testing.

Iron Carbon Diagram: Allotropic forms of carbon, solid and liquid state reactions, types of steels, types of cast irons, microstructures at various carbon percentages, properties as a function of microstructures, significance of IC diagram. Cooling curves and equilibrium diagrams for brass and aluminum alloys.

TTT Diagrams: Time temperature transformations diagram, transformations as a function of cooling rate, mechanism of various transformations, and significance of TTT diagram.

Heat Treatment Methods: Mechanism of annealing and advantages, mechanism of normalizing and advantages, mechanisms of tempering and advantages, mechanism of hardening and advantages, mechanism of case hardening and advantages, mechanism of induction hardening and advantages.

Chemical Heat Treatment Methods: Introduction to chemical heat treatment, mechanism and methods of carburizing, nitriding, cyaniding, introduction to flame hardening.

Hardenability: Meaning of Harden ability, tests of Hardenability, factors affecting Hardenability

Effect Of Alloying Elements: Effect on strength and hardness, effect on Hardenability, effect on transformation temperature

Books Recommended

1. Lakhtin Yu, "*Engineering Physical Metallurgy & Heat Treatment*", Mir Publishers (1990).
2. Dieter E G, "*Mechanical Metallurgy*", McGraw Hill Book Company (1988).
3. Shackelford F J, Murlidhara K M, "*Introduction to Materials Science for Engineers*", Pearson Education (2007).
4. Askerland RD, Phule P, "*The Science & Engineering of Materials*", Thomson Education (2006).
5. Van Vlack L.H, "*Elements of Material Science and Engineering*", Addison Wasley Publishers (1989).
6. Smith W F, "*Principles of Material Science and Engineering*", McGraw Hill, New York (1993).

MA - 201

Mathematics III

[3 1 0 4]

Limit and derivative of a complex function, Analytic functions and Cauchy Riemann equations, Line integral of elementary functions, Cauchy's integral theorem, Cauchy's integral formula and derivatives of analytic functions, Taylor and Laurent series, Zeros and singularities, Residues and residue theorem, Evaluation of real improper integrals, Conformal mappings, linear fractional transformations and mappings by elementary functions

Series solution, Special function, Bessel functions, Bessel function of first kind and solutions of Bessel equation, Bessel function of second kind, Some application of Bessel function, Modified Bessel function, Legendre's function

Calculus of variations- Fundamental concepts, functional of a single function, function involving several independent functions, one end fixed- other end free problems, both end free problems, constrained extrema.

Books Recommended

1. Grewal, B S, "*Higher Engineering Mathematics*", Thirty-fifth edition, Khanna Publishers, Delhi.
2. Elsgole L E, "*Calculus of Variations*", 1961 Pergamon Press, Addison-Wisley Publishing Company.

ME-202

Applied Thermodynamics-II

[3 1 0 4]

Introduction: Stagnation properties, sonic velocity and Mach number, Mach waves, Flow through Nozzles and diffusers, Metastable state and super saturated flow, thrust function. Flow through variable area, isentropic flow, adiabatic flow with friction; Flow through constant area with friction (Fanno Flow), Frictionless Flow through a constant area duct with heat transfer (Rayleigh Flow), Isothermal flow through a constant area duct, normal shock waves, Rankine-

Hugoniot equation, Strength of shock waves, application of gamma function to specific flow process.

Rotary Compressors: Classification of rotary compressors, comparison with reciprocating compressors, working of rotary compressors like Roots blower, Lysholm Compressor and Vane-type Blower.

Determination of total work done for compressors, energy loss in internal friction. Isentropic, polytropic and isothermal efficiencies of compressor.

Centrifugal Compressors: Thermodynamic analysis of centrifugal compressor: Stage, polytropic, isentropic and isothermal efficiencies, velocity vector diagrams for centrifugal compressors, power calculation, , pre-guided vanes, pre-whirl, Slip factor, power input factor. Modes of energy transfer in impeller and diffuser. Degree of reaction and its derivation, energy transfer in backward, forward and radial vanes, Derivation of Non-dimensional parameters for plotting compressor characteristics, surging and choking in centrifugal compressors. Various losses occurring in centrifugal compressors and application of centrifugal compressors.

Axial Flow Compressor: Components of axial flow compressor, aerofoil blading, angle of attack, coefficients of lift and drag, turbine versus compressor blades, velocity vector diagrams, thermodynamic analysis and power calculations. Modes of energy transfer in rotor and stator blade flow passages. Work done factor, Degree of reaction and Blade efficiency, Isentropic polytropic and Isothermal Efficiencies. Surging, choking and stalling in axial flow compressors, characteristic curves for axial flow compressor, flow parameters of axial flow compressor pressure coefficient, flow coefficient, work coefficient and temperature rise coefficient ,specific speed etc. Comparison of axial flow compressor with centrifugal compressor and reaction turbine. Application of axial flow compressors.

Gas Turbines: Classification, Open and closed cycle and their comparison. Application of gas turbine. Position of gas turbine in power industry. Thermodynamic analysis-Brayton cycle, calculation of net output, work ratio, and thermal efficiency , Operating variables and their effects on thermal efficiency and work ratio. Gas turbine cycle with regeneration, intercooling, multistage compression and expansion. Closed and semi closed gas turbine cycle, requirements of a gas turbine combustion chamber, types of combustion chambers, Pressure losses in heat exchangers and combustion chambers. Gas turbine fuels.

Jet Propulsion : Principle of jet propulsion, Performance characteristics of different propulsion systems, Application of various propulsion systems.

Books Recommended

1. Shepherd D G, "*An Introduction to Gas Turbine*", Von Nastrand, New York (1949).
2. Stodola A, "*Steam and Gas Turbines*", McGraw Hill Book Company, (1970).
3. Shapiro A M, "*Dynamics and Thermodynamics of Compressible Fluids*", Ronald's Press, New York (1953).
4. Benson R W, "*Advanced Engineering Thermodynamics*", Pergamon Press, London (1975).
5. Cohen H, Rogers G F C and Saravanamuttoo H I H, "*Gas Turbine Theory*", Orient Longman Limited, New Delhi (1996).

ME-204

Dynamics of Machines

[3 1 0 4]

Brakes and Dynamometers: Types of brakes, principle and function of various types of brakes, problems to determine braking capacity, different types of dynamometers.

Static Force Analysis: Static equilibrium, equilibrium of two-force and three-force members, members with two forces and a torque, free body diagram, principle of virtual work, friction in mechanisms.

Dynamic Force Analysis: D' Alembert Principle, dynamic analysis of four-link mechanisms and slider-crank mechanisms, analytical and graphical method, velocity and acceleration of piston, angular velocity and angular acceleration of connecting rod, piston and crank effort, inertia of connecting rod, inertia force in reciprocating parts.

Balancing: Static and dynamic balancing, balancing of several masses in different planes, Balancing of reciprocating masses, balancing of locomotive, partial balancing, direct and reverse crank method, balancing of inline engines and V-Engines, balancing machines.

Lower Pairs: Pantograph, straight line mechanisms, engine indicators, automobile steering gears, Hooke's joint and Double Hooke's joint.

Gyroscope: Effect of gyroscopic couple on supporting and holding structures of machines. Gyroscopic effect on naval and air ships and automobiles.

Flywheels: Turning moment diagram for steam engine and four-stroke internal combustion engine and for multicylinder engines, fluctuation of energy and speed in flywheels, size of flywheel and flywheel for punching press.

Books Recommended

1. Bevan T, *"The Theory of Machines"*, 3rd Edition CBS Publishers and Distributors (2002).
2. Shigley J E and Vickar J J, *"Theory of Machines and Mechanism"*, 2nd Edition, McGraw Hill, New Delhi (1995).
3. Wilson C and Sadler J, *"Kinematics and Dynamics of Machine"*, 3rd Edition, Prentice Hall (2002).
4. Ratan S S, *"Theory of Machines"*, 1st Edition, Tata McGraw Hill, New Delhi (1993).
5. Rao J S and Dukupati R V, *"Mechanism and Machine Theory"*, 2nd Edition, New Age International (P) Limited, Delhi (1992).

ME-206

Mechanics of Deformable Bodies

[3 1 0 4]

Strain energy: Energy of dilation and distortion, resilience stress due to suddenly applied loads, Castigliano's theorem, Maxwell's theorem of reciprocal deflection.

Theories of Failure: Maximum principal stress theory, maximum shear stress theory, maximum strain energy theory, maximum shear strain energy theory, graphical representation and derivation of equation for each and their application to problems relating to two dimensional stress systems only.

Distribution of Shear Stress in Beams: Derivation of general formula and its application to rectangular, triangular, I, C, T, L, circular and hollow sections.

Springs: Closed and open coiled helical springs: Derivation of formula and application for deflection and rotation of free end under the action of axial load and or axial couple; flat spiral springs – derivation of formula for strain energy, maximum stress and rotation. Leaf spring, deflection and bending stresses

Thick Cylinders: Derivation of Lamé's equations, calculation of radial longitudinal and hoop stresses and strains due to internal pressure in thick cylinders, compound cylinders, hub shrunk on solid shafts.

Bending of curved beams: Calculation of stresses in crane or chain hooks, rings of circular section and trapezoidal section and chain links with straight sides, Deflection of curved bars and rings.

Statically Indeterminant Systems: Force Method, Displacement method, Method of superposition and Analysis by differential equation of the deflection curve.

Unsymmetrical bending: Shear center for angle, channel and Z sections.

Rotational stresses: Discs and rims, discs of uniform strength.

3 D stress analysis: Analytical and graphical methods (Mohr's circle).

Fracture: Introduction to fracture and fracture mechanisms, stress concentration and its effects, cohesive strength of metals, Griffith's theory of brittle fracture, types and modes of fracture in metals, Notch effect.

Fatigue: Basic Principles of fatigue fracture, mechanism of fatigue, stress cycles, S-N curve, statistical nature of fatigue, effect of mean stress on fatigue, cyclic stress-strain curve, fatigue crack propagation, effect of stress concentration, surface effect and residual stresses on fatigue.

Books Recommended

1. Timoshenko, S P, James M and Gere, "*Mechanics of Materials*", 2nd Edition, CBS Publishers, New Delhi (1998).
2. Boresi A P, Schmidt R J and Sidebottom O M, "*Advanced Mechanics of Materials*", John Wiley and sons Inc, New York (1993).
3. Ryder GH, "*Strength of Materials*", 3rd Edition English Language Book Society / Macmillan Hongkong (2002).
4. Hibbeler, Russel C, "*Mechanics of Materials*", 4th Edition, Prentice Hall (2000).
5. Dieter G.E. "*Mechanical Metallurgy*", McGraw Hill, New York (1996).

ME-208

Production Processes

[3 1 0 4]

Attributes of Manufactured Products: Mechanical properties, physical properties, chemical properties, geometric attributes, material selection.

Machining and Machine Tools: Elements of machining, classification of machine tools, concept of orthogonal metal cutting.

Metal Casting: Casting alloys, solidification of metals, melting and pouring, casting processes, finishing processes, designs for casting.

Welding Processes: Survey of welding processes. Weldability of Steels, Cast irons, aluminum and Copper alloys, Joint Design and specifications, Inspection of welds.

Forming Processes: Rolling, Drawing, Extrusion, Forging, Press working and die design and High Velocity Rate Forming.

Powder metallurgy: Process details, component and die design considerations.

Processing of Plastics: Introduction and types of plastics, Properties of plastics, Materials required for processing plastics, Forming and Shaping of plastics, Comparison of plastic forming processes.

Jigs and Fixtures: Introduction, Production Devices, Advantages of Jigs and Fixtures, Elements of Jigs and Fixtures, Principles of Location and Clamping.

Process Planning: Definitions of process planning, contents of process planning, process operations, steps of process planning.

Books Recommended

1. Schey A J, "*Introduction to Manufacturing Processes*", McGraw Hill Book Company, New York (1987).
2. Sharma P C, "*Production Technology*", S Chand & Co, (2003)
3. DeGarmo E Paul, "*Materials & Processes in Manufacturing*", Wiley, 9th Edition.
4. Parmar R S, "*Welding Processes & Technology*", Dhanpat Rai Publishers.
5. Juneja B L, "*Fundamentals of Metal Cutting & Machine Tools*", New Age International (1998)

ME-210

Production Processes Laboratory

[0 0 2 1]

A small project covering the various aspects of Engineering from Design to Fabrication comprising of the following:

- (i) Preparation of Engineering Drawing on any CAD software – Weightage 20%
- (ii) Preparation of Bill of materials along with cost estimate (from market)- Weightage 10%
- (iii) Process Planning with details of Machines and tools required - Weightage 20%
- (iv) Completion of Project- Weightage 50%

NOTE: Group size of minimum 2 students and maximum 3 students shall be used.

ME-301

Design of Machine Elements

[3 0 2 4]

Scope and meaning of Design with special reference to machine Design, Design process.

Various considerations required for design of a component: Concept of tearing, bearing, shearing, crushing, bending etc. Selection of materials, mechanical behavior of materials, Stress concentration, factor of safety under different loading conditions, design stresses for variable and repeated loads, endurance limit, fatigue strength, limited life. Fits, tolerances and surface finish.

Fasteners and joints: Screws and screw jack, bolts, preloaded bolts subjected to shear, and torsion. Bolted, Welded and Riveted joints, eccentrically loaded welded and riveted joints, Cotter and cotter joints, pin fasteners, Knuckle joints.

Transmission shafts: Design of shaft subjected to static loading: pure torsion, simple bending, combined bending and torsion, combined bending torsion and axial loads. Design of shaft for fluctuating loads.

Keys: Different types of keys and splines, representations and use in Couplings.

Rigid couplings: Sleeve couplings, Flange couplings, Flexible couplings: Bush pin type, Universal type.

Levers: Hand and foot levers, cranked lever.

Gaskets, seals, Pipe joints: Oval, circular and square pipe joints.

Brakes and Clutches: Brakes: Design consideration of brakes, Flat plate, and conical plate clutches.

Books Recommended

1. Norton L R, *“Machine Design an Integrated Approach”*, Pearson Education Asia, 1st Indian Reprint (2001).
2. Sharma P C and Aggrawal D K, *“A text book on Machine Design”*, S K Kataria & sons, 9th Edition (2000).
3. Bhonsle R S and Weinmann J K, *“Mathematical modeling for Design of Machine Components”*, TK Integrated, Prentice Hall (1999).
4. Spotts M F and Shoup T E, *“Design of Machine Elements”*, Prentice Hall Seventh Edition (1998).
5. Shigley J E and Mischke C R, *“Mechanical Engineering Design”*, Tata Mcgraw Hill, New Delhi (2003).
6. Bhandari V. B., *“Design of Machine Elements”*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2nd edition (2007)

ME-303

Heat Transfer

[3 1 0 4]

Introduction: Concept of heat transfer, Difference between the subject of "Heat Transfer" and its parent subject "Thermodynamics". Different modes of heat transfer: conduction, convection and radiation.

Conduction: Fourier's law of heat conduction, coefficient of thermal conductivity, effect of temperature and pressure on thermal conductivity of solids, liquids and gases and its measurement.

Three- dimensional general heat conduction equation in rectangular, cylindrical and spherical coordinates. Derivation of equations for simple one dimensional steady state heat conduction from three dimensional equations for heat conduction through walls, cylinders and spherical shells (simple and composite), electrical analogy of the heat transfer

Equivalent areas, shape factor, conduction through edges and corners of walls and critical thickness of insulation layers on electric wires and pipes carrying hot fluids. Internal generation cases along with some practical cases of heat conduction like heat transfer through underground electrical cables, simple model of heat conduction through piston crown and case of nuclear fuel rod with cladding.

Influence of variable thermal conductivity on conduction. Introduction to unsteady heat transfer, Newtonian heating and cooling of solids; thermal diffusivity.

Theory of Fins: Straight rod type fins of uniform cross-section;. Straight fins with varying cross-sectional area and having triangular or trapezoidal profile area, circumferential fin of rectangular cross-section provided on the circumference of a cylinder. Optimum design of straight fin of rectangular and triangular cross-sections; fin effectiveness and fin efficiency. Application of fins in temperature measurement of flow through pipes and determination of error in its measurement.

Convection: Free and forced convection, derivation of three dimensional mass, momentum and energy conservation equations (with introduction to Tensor notations). Boundary layer formation, laminar and turbulent boundary layers (simple explanation only and no derivation). Theory of dimensional analysis as applied to free and forced convective heat transfer. Analytical formula for heat transfer in laminar and turbulent flow, flow over vertical and horizontal tubes and plates.

Newton's law of cooling. Overall coefficient of heat transfer. Different design criterion for heat exchangers. Log mean temperature difference for evaporator and condenser tubes, parallel and counter flow heat exchangers. Calculation of number and length of tubes in a heat exchanger.

Convection with Phase Change: (Boiling and Condensation) Pool boiling, forced convection boiling, heat transfer during pool boiling of a liquid. Nucleation and different theories of nucleation, different theories accounting for the increased values of heat transfer coefficient during nucleate phase of boiling of liquids; different phases of flow boiling (theory only)

Radiation: Process of heat flow, definition of emissivity, absorptivity, reflectivity and transmissivity. Concept of black and grey bodies, Planck's law of monochromatic radiation. Kirchoff's law and Stefan Boltzman's law. Interchange factor. Lambert's Cosine law and the geometric factor. Intensity of Radiation, radiation density, irradiation, radiosity and radiation shields. Derivation of formula for radiation exchange between two bodies using the definition of radiosity and irradiation and its application to cases of radiation exchange between three or four bodies (e.g. boiler or other furnaces). Error in Temperature measurement by a thermocouple probe due to radiation losses.

Books Recommended

1. Holman J P, "*Heat Transfer*", McGraw Hill Book Company (1997).
2. McAdam W H, "*Heat Transmission*", McGraw Hill Book Company, New York (1954).

3. Drake R M and Eckert E R G, "*Heat and Mass Transfer*", McGraw Hill, Kogakusha (1972).
4. Kreith F, "*Principles of Heat Transfer*", PWS Publishing Company, Boston (1997).
5. Rao Y V C, "*Heat Transfer*", University Press, Hyderabad (2001).

ME-305

IC Engines and Emission Control

[3 1 0 4]

Introduction to IC Engines: Heat Engine versus Internal combustion Engine, Historical development of IC Engines, Classification and Nomenclature, Applications of IC Engines. Review of Air standard cycles: Carnot, Sterling, Ericsson, Otto, Diesel and Dual Cycle etc.

Working of IC Engines: Working of 4 stroke SI and CI Engines and their valve timing diagram, working of 2-stroke SI and CI engines and their valve timing diagrams, Comparison of two stroke and four stroke Engines, Fuel Air Cycles and their analysis: Composition of cylinder gases, variable specific heats, Dissociation, Effect of number of moles, Air standard versus fuel air cycles, Effect of operating variables like compression ratio, fuel air ratio. Actual engine cycles and losses: Comparison between Actual, Fuel- Air cycle, Air standard cycles for S.I. and C.I engines.

IC Engine Fuels: Requirements of fuel in I C engines, Type of Fuels- Solid, Liquid and Gaseous fuels, Chemical structure of petroleum, petroleum refining process, Important qualities of SI and CI engine fuels and their ratings. Combustion of Fuels: Heating values of Fuels, Theoretical determination of heat of reactions of fuel, Combustion equation for Hydrocarbon fuels, Determination of minimum air required for combustion, conversion of volumetric analysis to mass analysis, Determination of air supplied from volumetric analysis of Dry flue gases, Determination of excess air supplied, Determination of percentage of carbon from exhaust gas composition.

Mixture Preparation Systems: Fuel supply system and fuel pumps, Simple carburetor and its working, approximate analysis of single jet carburetor, Actual Air fuel calculation of single jet carburetor, Ideal requirements from an ideal carburetor, limitations of single jet carburetor, Different devices used to meet the requirements of an ideal carburetor, Different modern carburetors, Petrol injection. Fuel Injection systems for CI Engines: Classification of Injection Systems, Injection Pump, Fuel Injector, Nozzle, and Injection in SI Engines.

Combustion in SI Engine: Stages of Combustion in S I Engine, flame front propagation, factors influencing the flame speed, ignition lag and factors affecting the ignition lag, Abnormal combustion and knocking, control and measurement of knock, Anti knock agents, combustion chambers of S I engines.

Combustion in CI Engines: Stages of combustion, Delay period, factors affecting delay period; detonation and factors affecting detonation; comparison of abnormal combustion in SI & CI engine, rating of IC engine fuels, combustion chambers for IC engines.

Supercharging: Purpose of supercharging, types of superchargers. Analysis of superchargers. Arrangement of supercharger and its installation, turbo charged engines, supercharging of SI & CI engines, limitations of supercharging.

Measurement and Testing: Measurement of Friction Power, Brake Power, indicated Power, Measurement of Speed, Air consumption, fuel consumption, heat Balance Sheet for engine, governing of IC Engines. Performance Characteristics of IC Engines: Performance parameters, performance of SI engines, performance of C.I. engines, Engine performance maps.

Emission and Control. Emission of various pollutants from the engine, kinetics of NO_x formation, NO formation in S.I. engines, NO_x formation in C.I. engines, Emission of carbon monoxide, HC emission in S.I. engine and hydrocarbon emission in C.I engine, particulate emissions in S I engine, characteristics of diesel particulates, Soot formation fundamentals, Exhaust gas treatment: Catalytic convertors, Thermal reactors, Particulate traps.

Books Recommended

1. Heywood J B, "*Internal Combustion Engine Fundamentals*", McGraw Hill, Publication, New Delhi (1988).
2. Taylor C F, "*The Internal Combustion in Theory and Practice*", Volume I and II, MIT Press, Cambridge, Mass (1968).
3. PulkRabek W W, "*Engineering Fundamentals of Internal Combustion Engine*", Pearson Education, New Delhi (2003).
4. Stone R, "*Introduction to Internal Combustion Engines*", 2nd Edition, Macmillan (1993).
5. Milton B E, "*Thermodynamics, Combustion and Engines*", Chapman and Hall (1995).

ME-307

Mechanical Measurement and Metrology

[3 0 0 3]

General Concept: Need and classification of measurements and instruments, Standards, Calibration, basic and auxiliary functional, elements of a measurement system, mechanical versus electrical/electronic instruments, primary, secondary and working standards.

Static and Dynamic Characteristics of Instruments: Range and span, accuracy and precision, Calibration, hysteresis and dead zone, sensitivity and linearity, threshold and resolution, speed of response, lag, fidelity, and dynamic errors, dead time and dead zone. Sources of errors in measurements, Basic concepts of measurement methods, Processing of experimental data, curve fitting. regression analysis and Uncertainty analysis

Functional Elements: Review of electro-mechanical sensors and transducers-variables resistance, inductance and capacitive pick-ups, resistance strain-gauges, gauge-factor, bonded and unbonded strain gauges, surface preparation and Bonding Techniques, application of strain-gauges for direct, bending and torsional loads, hydraulic and pneumatic load cells.

Temperature Measurement: Bimetallic thermometers, liquid-in-glass thermometers and filled-in-system Thermometers, thermocouples, metal resistance thermometers and thermistors.

Pressure and Flow Measurement: Bourdan Tube, Vacuum Measurement-Mcleod Gauge, Thermal Conductivity gauge and Ionization gauge. Electromagnetic flux-meters, Ultrasonic Flow meters and Hot Wire anemometers.

Force, Torque and Power Measurement: Vibration Reed tachometer, Stroboscope, Proving Ring, Mechanical and Hydraulic Load cell, Torque on rotating shafts, Absorption, transmission and driving dynamometers.

Data Sampling and Data Acquisition: Sampling concepts, Data Acquisition systems and its components

Metrology: linear Measurements-Vernier caliper and vernier height gauge. Angular Measurements: Sine bar, clinometers, angle gauges, vernier bevel protector, Comparators: Their types, relative merits and limitations, use of comparators, construction of Mechanical, electrical & optical comparators, Measurement of tooth thickness, pitch and checking of profile for spur gears, Measurement of major diameter, minor diameter, effective diameter pitch, angle of screw thread.

Books Recommended

1. Holman J P, "*Experimental Methods for Engineers*", 6th Edition, McGraw Hill Inc (1994).
2. Doebelin E O, "*Measurement System Application and Design*", 5th Edition, McGraw Hill, Singapore (2004).
3. Beckwith T G, Marangoni R D and Lienhard J H, "*Mechanical Measurements*", 5th Edition, Pearson Education India, (1993).
4. Jain R K, "*Engineering Metrology*", 3rd Edition Khanna Publishers, Delhi (1998).

5. Figloila RS and Beasley D E, “*Theory and Design for Mechanical Measurements*”, 2nd Edition, John Wiley and Sons Inc, New York (1995).

ME 309

Mechatronics

[3 0 0 3]

Introduction: Mechatronics: What and Why?

Essential electronics and Boolean algebra:

Digital representation: Binary, Decimal, Hexadecimal, Conversion from Binary to Decimal and vice-versa,

Binary arithmetic: Addition, Subtraction: 2’s complement, Multiplication and Division, Boolean algebra: AND, OR, NOT, NAND, NOR, XOR logic, Truth table, Realization of logic in physical systems: switches-LEDs, cylinders...

Fundamental identities, De Morgan’s theorems and relationship with sets, Simplification,

Electronics fundamentals: Review of some semiconductor devices, Concepts of Digital and Analog systems, Digital output (DO) and input (DI), Using switches, transistors, pneumatic devices, etc. to realize DI & DO,

Operational Amplifier: Principles, Configurations: Inverting; Summing; Integrating and Differentiating configurations, Digital to Analog conversion (DAC), The R-2R and summing Op-Amp circuit, Analog to Digital conversion (ADC), Successive approximation method, Flash method, etc.,

Programs for DI, DO, DA and AD for PC based plug in cards,

Microprocessor, Computers and Embedded systems:

Introduction to the 8085 (8-bit microprocessor) and microcontroller: Architecture, programming, I/O, Computer interfacing,

Programmable logic controller basics

Sensors and actuators

Strain gauge, resistive potentiometers, Tactile and force sensors, tachometers, LVDT, Piezo electric accelerometer, Hall effect sensor, Optical Encoder, Resolver, Inductosyn, Pneumatic and Hydraulic actuators, stepper motor, DC motor, AC motor

Control Systems:

Mathematical modeling of Physical systems, System equations, Controllability and Observability, Pole placement, PID controller, Control of Hydraulic, Pneumatic, Mechanical and Electrical Systems

Integration and case studies:

Integration of Mechatronics component subsystems into a complete Mechatronics system

Applications to CNC machines and Robotics

Recommended Books

1. David G. Alciatore, and Michael B. Histan, “*Introduction to Mechatronics and Measurement Systems*”, 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi (2007).
2. W.Bolton, “*Mechatronics*”, 2nd Edition, Pearson Education Asia, New Delhi (2001).
3. Dan Necsulescu, “*Mechatronics*”, Pearson Education Asia, New Delhi (2002).
4. N. P. Mahalik, “*Mechatronics*”, Tata McGraw Hill Publishing Company Ltd., New Delhi (2003).
5. Wolfram Stadler, “*Analytical Robotics and Mechatronics*”, McGraw-Hill Book Co., Singapore (1995).
6. Eronini Umez-Eronini, “*System Dynamics & Control*”, Thomson Asia Pvt. Ltd., Singapore (1999).

General Concepts: Impulse momentum principle, jet impingement on stationary and moving flat plates, and on stationary or moving vanes with jet striking at the center and tangentially at one end of the vane, calculations for force exerted, work done and efficiency of jet. Basic components of a turbomachine and its classification on the basis of purpose, fluid dynamic action, operating principle, geometrical features, path followed by the fluid, Euler's equation for energy transfer in a turbomachine and specifying the energy transfer in terms of fluid and rotor kinetic energy changes.

Pelton Turbine: Components and its operation, velocity triangles for different runners, work output, Effective head, available power and efficiency; design aspects such as mean diameter of wheel, jet ratio, number of jets, number of buckets with working proportions.

Francis and Kaplan Turbines: Components and operation, velocity triangles and work output; working proportions and design parameters for the runner; Degree of reaction, draft tubes - its function and types. Function and brief description of commonly used surge tanks.

Centrifugal Pumps: Layout and installation; Main elements and their functions, Various types and classification, Pressure changes in a pump - suction, delivery and manometric heads, vane shape and its effect on head-capacity relationships, Departure from Euler's theory and losses, pump output and efficiency, Minimum starting speed and impeller diameters at the inner and outer periphery, Priming and priming devices, Multistage pumps - series and parallel arrangement; submersible pumps. Construction and operation, Axial and mixed flow pumps, Trouble shooting - field problems, causes and remedies.

Similarity Relations and Performance Characteristics: Unit quantities, specific speed and model relationships, scale effect, cavitation and Thoma's cavitation number; Concept of Net Positive Suction Head (NPSH) and its application in determining turbine / pump setting.

Reciprocating Pumps: Components parts and working, pressure variations due to piston acceleration, acceleration effects in suction and delivery pipes, work done against friction, maximum permissible vacuum during suction stroke, Air vessels.

Hydraulic Devices and Systems: Construction, operation and utility of simple and differential accumulator, intensifier, fluid coupling and torque converter, Air lift and jet pumps; introduction to gear, vane and piston pumps.

Books Recommended

1. Daughaty R L, "*Hydraulic Turbines*", McGraw Hill Book Company (1965).
2. Jagdish Lal, "*Hydraulic Machines*", Metropolitan Book Company Private Limited, New Delhi, (2000).
3. Stepanoff A J, "*Centrifugal and Axial Flow Pumps*", John Wiley and Sons (1970).
4. Binder R C, "*Advanced Fluid Mechanics and Fluid Machinery*", Prentice Hall (1966).
5. Nechleba M, "*Hydraulic Turbine*", Constable and Company (1957).

Introduction: Basic concept of Automation, Types of Automation, Feasibility etc.

Industrial Hydraulics: Introduction, basic concepts, Hydraulic fluids, Classification and properties of hydraulic fluids, Contaminates in hydraulic system, control and cleanliness standards, Fluid power generators, i.e. Gear, Vane, Piston pumps, linear and Rotary Actuators, Direction Control Valves, types, actuation methods, pressure control valves; pressure reducing valves, pressure relief valve, Unloading valve, Sequence valve, Counterbalance valve, Flow control valves simple and pressure compensated type. Standard ISO Symbols for Hydraulic

Components. Sealings in hydraulic system, Accumulators, hydraulic hoses and tubing, Design and analysis and hydraulic circuits, conventional as well as computer aided design.

Pneumatics: Introduction, Basic components, Source, storage and distribution, treatment of compressed air, linear and Rotary actuators, Direction control valves – types, actuation methods, pressure control valves, logic devices – twin pressure valve, shutter valve, time delay valve, Pneumatic circuit design and analysis, conventional as well as computer aided design.

Automatic Assembly System: Development of Automatic Assembly process, Transfer devices – continuous, Intermittent, synchronous and asynchronous, Vibratory feeders – Mechanics, effect of frequency, acceleration, track angle, friction, load sensitivity, orientation of parts – active and passive devices, Mechanical feeders – computation and operational details, feed tracks, Escapement devices. Product design for high-speed automatic assembly, examples of design modifications.

Mechatronics: Introduction mechatronic system design, sensors and transducers for displacement, proximity, velocity, force, pressure temperature measurement. Microprocessors – Introduction, structure micro-controllers, application programmable logic controllers – basic structure, specifications programming of PLC's, importance of Timers, Counters, marker relays, analog comparators in PLC programming, Introduction to Data Acquisition and virtual instrumentation using LABVIEW.

Robotics: Basic concepts, classification based on Geometry, programming, drives, work volume of robots world and joint coordinates various joints, DOF, end effectors – Types and uses, Sensors in Robots, programming – Teach pendant and Computer programming, Introduction to forward and inverse kinematics, Applications of Robots.

Books Recommended

1. Anthony Esposito, "*Fluid Power with Application*", 5th Edition, Pearson Education (2003).
2. Majumdar S R, "*Oil Hydraulic System*", Tata McGraw Hill (2001).
3. Bolton W, "*Mechatronics*", 2nd Edition, Pearson Education, New Delhi (1999).
4. Necsuleescu Dan, "*Mechatronics*", Pearson Education, New Delhi (2002).
5. Geoffrey Boothroyd, "*Assembly Automation and Product Design*", Marcel Dekker Inc (1991).

ME-306

Production Management

[3 0 0 3]

Introduction: Definition and scope of industrial engineering, Role of industrial engineer in industry. Qualities of an Industrial Engineer.

Work Study: Productivity and the standard of living, reducing work content and ineffective time, the human factor in the application of work-study, Working conditions and the working environment.

Method Study: Introduction of method study and the selection of jobs, Methods and movements at the workplace.

Work Measurement: Introduction, Work sampling, Time Study, equipment, timing the job, rating, Calculation of standard time, Setting time standard for works and machines, Predetermined time standards, Standard data and its use. Specific case studies.

Value Engineering: Types and concept of value engineering, phases of value engineering studies, application of value engineering.

Job Design: Traditional engineering dimensions of job design, Concepts of job enlargement, Job enrichment, Job rotation, effective job design in relation to technological and behavior factors.

Ergonomics: Introduction, Considerations in designing man machine systems with special reference to the design of displays and control.

Maintenance Management: Introduction, types, total productive maintenance, condition monitoring.

Books Recommended

1. Barnes M R, "*Motion and Time Study*", John Wiley and Sons (2002).
2. Osborne D J, "*Ergonomics at Work*", John Wiley and Sons (1985).
3. Miles, "*Techniques of Value Analysis and Engineering*", 2nd Edition, McGraw Hill (1997).
4. Ulrich Cart T and Eppinger Steven D, "*Product Design and Development*", Tata McGraw Hill, New Delhi (1995).
5. Hicks, "*Industrial Engineering and Management*", 2nd Edition, Tata McGraw Hill, New Delhi (1994).

ME-308

Fluid Machinery Laboratory

[0 0 2 1]

1. Determination of various efficiencies of Hydraulic Ram.
2. To draw characteristics of Francis turbine.
3. To study the constructional features of reciprocating pump and to perform test on it for determination of pump performance .
4. To draw the characteristics of Pelton Turbine.
5. To draw the various characteristics of Centrifugal pump.
6. Determine the effect of vane shape and vane angle on the performance of centrifugal fan.

ME-310

Industrial Automation & Mechatronics Laboratory

[0 0 2 1]

1. Study of various pneumatic components and Assembly and operation of some basic pneumatic circuits using pneumatics transfer package.
2. Study of various electro-pneumatic Components and Assembly and operations of some basic and advanced electro-pneumatic, PLC controlled pneumatic circuits using pneumatics trainee package.
3. Study of various components in hydraulic circuits. Assembly and operation of some basic hydraulic and electro-hydraulic circuits.
4. Study the basic geometry motions of Jointed Arm Robot. Teach Pendant programming of the robot using various basic and advanced programming techniques i.e. WAIT commands etc.
5. Study the operation of Hydraulic circuit simulation software and using the same for drawing and simulating some hydraulic circuits.
6. Study the operation of pneumatic circuit simulation software and using the same for drawing and simulating some pneumatic circuits.
7. Study the basic features of a PLC. Programming of the ABB, PLC for various logic and regulated decisions.
8. Study the basic features of a programmable motion controller programming of the DC servo motion controller and its accessories for simple programs.
9. Study the operation of a Robotics simulation software and simulation of some basic robot configuration using Industry specific language.

Approximation and Errors: Accuracy of numbers, Errors in approximations, Order of approximation, Propagation of errors.

Roots of Algebraic and Transcendental Equations: Bisection method, Regula-falsi method, Iteration method, Newton-Raphson method, Bairstow's method, Graeffe's root squaring method.

Solution of Simultaneous Algebraic Equations: Matrix Inversion and Eigen-value Problems, Triangularisation method, Jacobi's and Gauss-Seidal iteration methods, Newton-Raphson method for nonlinear simultaneous equations, Triangularisation method for matrix inversion, Partition method for matrix inversion, Power method for largest eigen-values, Jacobi's method for finding all Eigen-values

Finite Differences Interpolations and Numerical Differentiations: Forward, Backward, Central differences and relations between them, Newton's forward, backward and divided difference interpolation formulas, Lagrange's interpolation formula, Stirling's and Bessel's central difference interpolation formulas, Numerical differentiations using Newton's forward and backward difference formulas, Numerical differentiations using Stirling's and Bessel's central difference interpolation formulas

Numerical Integrations: Trapezoidal rule, Simpson's one-third rule, Numerical double integrations using Trapezoidal rule and Simpson's one-third rule.

Numerical Solution of Differential Equations:

- (i) **Ordinary Differential Equations:** Taylor's series method, Euler's and modified Euler's methods, Runge-Kutta fourth order methods, Above methods for Simultaneous first order differential equations, Above methods for second order differential equations.
- (ii) **Boundary Value Problems:** Finite difference methods for Boundary Value Problems.
- (iii) **Partial Differential Equations:** Finite difference methods for Elliptic, Parabolic and Hyperbolic equations.

Books Recommended

1. Ames W F, "Numerical Methods for Partial Differential Equations", 3rd Edition, Academic Press, New York (1992).
2. Dahlquist G and Björck A, "Numerical Methods", Prentice-Hall, NJ (1974).
3. Jain M K, Iyengar S R K. and Jain R K, "Numerical Methods for Scientific and Engineering Computations", 4th Edition New Age International (P) Limited, Publishers, New Delhi (2003).
4. Shampine L F, "Numerical Solution of Ordinary Differential Equations", Chapman and Hall, New York (1994).
5. Shampine L F, "Fundamentals of Numerical Computing ", Wiley, New York (1996).

Suggested Practices on Numerical Methods

Students are required to develop C++ program for following numerical methods:

1. Regula-falsi method
2. Newton-Raphson method
3. Triangularisation method
4. Gauss-Seidal iteration method
5. Power method
6. Lagrange's interpolation method
7. Simpson's integration rule
8. Runge-Kutta fourth order method for ordinary differential equations

9. Numerical solution of Laplace equation

10. Numerical solution of Heat equation

This is only the suggested list of practicals, Instructor may frame additional practical exercises relevant to the course contents.

ME-401

Refrigeration and Air Conditioning

[4 0 0 4]

Basic Concept: Natural and Mechanical Refrigeration, Application of refrigeration, Units of refrigeration and Coefficient of performance, Refrigeration effect, cooling capacity and COP of a refrigerator, heating effect, heating capacity and COP as heat pump.

Bell Coleman Cycle and Aircraft Refrigeration: Bell Coleman Cycle and its analysis; optimum COP and pressure ratio, necessity of air craft refrigeration – air cycle refrigeration systems and their comparison.

Vapour Compression Refrigeration Cycle: Vapour compression cycle on P-V, P-H and T-S diagrams, deviation of actual cycle from theoretical cycle, compressor capacity and volumetric efficiency, analysis of theoretical and actual vapour compression cycles, effect of suction pressure, discharge pressure, sub-cooling, super heating and pressure drop in valves on performance and cooling capacity.

Vapour Compression Refrigeration with Multiple Evaporators and Compressors: Compound compression with single and multiple expansion valves, water inter-cooling and flash inter-cooling, multiple load systems with single and multiple expansion valves.

Vapour Absorption Refrigeration Cycle: (No Mathematical Analysis) Principle of absorption system; components of the system, Desirable properties of absorption system refrigerant and absorbent, Aqua– ammonia absorption refrigeration system, Lithium Bromide–water absorption refrigeration system; Lithium Bromide–water absorption system, Comparison between absorption and compression system.

Refrigerants: Classification and nomenclature of refrigerants, Desirable thermodynamic, chemical and physical properties of refrigerants, comparative study of commonly used refrigerants and their fields of application; Azeotropes, Effect of moisture and oil miscibility, Refrigerant drying agents and antifreeze solution, leak detection and charging of refrigerants, environmental, aspects of conventional refrigerants, friendly refrigerants.

Non-Conventional Refrigeration Systems (No Mathematical Analysis): Cascade Refrigeration System, Linde and Claude cycles for liquefaction of gases

Air Conditioning: Concept and Applications, Psychometric properties of air, Dry bulb, wet bulb and dew point temperatures; Relative and specific humidity; degree of saturation, adiabatic saturation temperature, enthalpy of air and water vapours, psychometric chart. Human requirements of comforts, effective temperature and comfort charts, Industrial and comfort air conditioning.

Psychrometric Process: Sensible heating and cooling, cooling with dehumidification, Heating with dehumidification, by-pass factor, chemical dehumidification, adiabatic mixing, air washer. Cooling and heating load estimation

Refrigeration and Air Conditioning Equipment: Brief description of compressors, condensers and evaporators and expansion devices, Cooling towers.

Books Recommended

1. Arora C P, “*Refrigeration and Air Conditioning*”, 19th Edition, Tata McGraw Hill, Delhi (1985).
2. Prasad M, “*Refrigeration and Air Conditioning*”, 2nd Edition, New Age International Private Limited, Delhi (2002).

3. Dossat, R J, "*Principles of Refrigeration*", 4th Edition, Pearson Education (Singapore), India, (2002).
4. Mcquiston F G, Parker J D and Spiliter J D, "*Heating, Ventilating, and Air Conditioning*", 5th Edition, John Wiley and Sons Inc, New York (2001).
5. Jordan and Priester, "*Refrigeration and Air Conditioning*", Prentice Hall of India (1998).
6. Ananthanarayan, "Basic Refrigeration and Air Conditioning", 3rd Edition, Tata McGraw Hill

ME-403

CAD/CAM

[2 0 4 4]

Introduction of CAD/CAM: History of CAD/CAM, market trend of CAD/CAM, Role of computers, Computer Aided Engineering, Computer Aided Manufacturing, Benefits of CAD.

Hardware and software of CAD/CAM: types of system, systems evaluation criteria, input and output devices, hardware integration and networking, graphics standards, data structure, database management system, modes of graphics operations, user interface, software models, efficient use of softwares,

Geometric Modeling: Wire frame, Surface and Solid models, mathematical representation of curves, parametric representation of analytical and synthetic curves, curve manipulation, mathematical representation of surfaces, plane surface, ruled surface, Bezier surfaces, B-spline surfaces, coons surfaces, blending surfaces. Fundamental of solid modeling, half spaces, boundary representation. Solid modeling based applications Data exchange, IGES, PDES, geometrical transformations and visual realism.

Finite Element Analysis: Introduction, Procedures, Element types, Nodal approximation, Element matrices, vectors and equations, Global connectivity, Assembly, Boundary conditions, Solution techniques, Interfaces to CAD, Introduction packages, Software development for design of mechanical components.

Computer Aided Manufacturing: Evolution of Computer Numerical Control, Components, Co-ordinate system, Working principle of CNC Lathe, Turning Centers, Milling Machine, Machining Center, Drilling Machine, Boring Machine,

Part Program Terminology: G and M Codes, Types of interpolation, Methods of CNC part programming, Manual part programming, Computer Assisted part programming: APT language , CNC part programming using CAD/CAM-Introduction to Computer Automated Part Programming.

Books Recommended

1. Groover and Zimmers, "*CAD / CAM: Computer Aided Design and Manufacturing*", Prentice Hall of India, New Delhi (1994).
2. Ramamurthi V, "*Computer Aided Mechanical Design and Analysis*", Tata McGraw Hill Publishing Co Ltd (1998).
3. Ibrahim Zeid, "*CAD - CAM Theory and Practice*", Tata McGraw Hill Publishing Co. Ltd (1991).
4. Steave Krar and Arthur Gill, "*CNC Technology and Programming*", McGraw-Hill Publishing Company (1990).
5. Radhakrishnan P, Subramanyam S, Raju V , "*CAD/ CAM/CIM*", New Age International Publishers (2000).

List of practical in CAD/CAM

- 1 Introduction of various commands used for working with layers and layer groups is AutoCAD Mechanical: Changing a layer by selecting objects, Creating layer groups ,Using a layer group to copy object
- 2 Design of lever: Lever inserted from the parts library, and then you refines the design using many of the design options, Inserting a library part, Preliminary setting: snap configuration, Creating construction lines, Creating a contour and applying a fillet, Creating a contour and applying a fillet, Creating a contour and trimming projecting edges, Cross- hatching the lever, Dimensioning the lever, Creating a detail and additional dimensions
- 3 Calculate a chain length, and insert sprockets and chain links into a drawing: Performing a length calculation Optimizing the chain length, Inserting sprockets, Inserting a chain
- 4 Calculate a spring for existing boundary conditions and insert the spring into a drawing: Starting the spring calculation, Specifying the spring restrictions, Calculating the selecting the spring, Inserting the spring, Copying the spring with Power Copy, Editing the spring with Power Edit
- 5 Design of shaft: Create a shaft with cylindrical and conical sections, Add threads and a profile to the shaft, Edit the shaft, Add Standard part of the shaft, Shade and display 3 D views of the shaft.
- 6 Analysis with FEM: Start a finite element analysis, Define stress loads, Generate a mesh, Calculate and display the result
- 7 Design a cam, perform calculations and generate data for NC Production: Starting the cam design and calculation, Defining the motion sections, Calculating the strength, Exporting cam data and viewing the result.
- 8 Part-programming on CNC machines
- 9 Execution of part programme for machining given profile.
- 10 Programming of robots for various applications

ME-405

System Design

[3 0 2 4]

System Design involves preparing of complete design of system, production drawings for selected projects in power drive, engines, machine tools, mechanical handling equipment etc.

Books Recommended

1. Norton L R, *“Machine Design an Integrated Approach”*, 1st Indian Reprint, Pearson Education Asia (2001).
2. Sharma P C and Aggrawal D K, *“A text book on Machine Design”*, 9th Edition, S K Kataria and sons (2000).
3. Shigley J E and Mischke C R, *“Mechanical Engineering Design”* Tata Mcgraw Hill, New Delhi, (2003).
4. Acherkan N, *“Machine Tool Design”*, Volume 1 to 4, MIR Publishers, Moscow (1969).
5. Burr H and John B Cheatham, *“Mechanical Analysis and Design”*, PHI Private Limited, New Delhi (2001).

ME-407

Metal Cutting and Machine Tools

[3 0 2 4]

Machining of Metals: Mechanics of metal cutting, Cutting Tool Nomenclature, Orthogonal and Oblique Cutting, Tool Angle Specification Systems, Effect of Cutting Parameters on Tool Geometry, Temperature at the Shear Plane in orthogonal Cutting, Experimental Determination of Tool Temperature.

Tool Wear and Cutting Fluids: Cutting Fluids, Types of Cutting Fluids, Selection of Cutting Fluids, Methods of Applying Cutting Fluids, Kinds of Tool Damage, Tool Wear Equation, Tool Life Equations, Tool Life Tests.

General Purpose Machine Tools and Operations: Lathe and turning operations, Lathe and its accessories, Lathe specifications, lathe cutting tools, Classification of milling machines, specifications of milling machine, milling machine operations, indexing methods: simple and compound indexing. Shaper and Planes, Grinding Machines, Drilling Machines.

Introduction to new Machining Processes.

Mechanisms for rectilinear motion: Methods for producing rectilinear motion in machine tools, Rack and pinion drives, rotary and materials uses for pinions and racks, worm and rack drives, materials used, lead screw and nut drives, materials used for bad screws and nuts.

Structural Features of Machine Tools: Beds, Bases columns, material for beds, bases and columns typical constructions of beds, bases and columns, machine tool columns, Housings, Tables cross rails and carriages.

Frames and Guides: Sideways, Antifriction ways, circular ways.

Speed and Feed Gear Boxes: Speed gearboxes in machine tools, types of speed gearboxes, feed gearboxes, types of feed gearboxes.

Introduction to Numerical Control of Machine Tools.

Installation and maintenance of machine tools: Machine Tool installation and maintenance safety in machine tools, reconditioning of machine tools, trouble shooting.

Books Recommended

1. Devris W R, *“Analysis of Material Removal Processes”*, Springer – Verlag (1992).
2. Panday P C and Shan H S, *“Modern Machining Processes”*, Tata McGraw Hill Publishing Company Limited, New Delhi (1980).
3. Schey A John, *“Introduction to Manufacturing Processes”*, McGraw Hill Book Company, New York (1987).
4. HMT Bangalore, *“Production Technology”*, Tata McGraw Hill, New Delhi (1980).
5. Acherkan N, *“Machine Tool Design”*, Volume 1 to 4, MIR Publishers, Moscow (1969).

ME-409

Refrigeration and Air Conditioning Laboratory

[0 0 2 1]

1. To find out the coefficient of performance of vapour compression refrigeration test rig using
 - (a) Capillary tube as an expansion valve.
 - (b) Thermostatic expansion valve.
2. To find out the EPR (Energy Performance Ratio) of a Mechanical Heat Pump based on vapour compression refrigeration cycle.
3. To study the working of Electrolux vapor absorption refrigeration systems using three fluids.
4. To study the window type air conditioning test rig and performing the experiments related to basic air conditioning processes.
5. To study the ice plant test rig.
6. To study the effect of variation of brine concentration on the formation of ice.
7. To study the cut sections of reciprocating compressor of window type air conditioner.
8. To study the working of window air conditioner

Introduction: Basics of vibration, its effects, Harmonic and non-harmonic motions, kinetic and potential energy, Conservative non-conservative system in reference to vibrations.

Single Degree Freedom System: Free vibrations of systems without damping, equilibrium and energy methods, Rayleigh's method, equivalent system, systems with compound springs, shafts of different diameters, free vibrations with viscous damping, logarithmic damping, coulomb and structural damping etc., Forced vibration with viscous damping, equivalent viscous damping, impressed force due to unbalanced masses and excitation of supports, jump phenomenon, vibration isolation, Transmissibility, commercial isolators.

Two Degree Freedom Systems: Free undamped vibrations, static and dynamic coupling, principal modes of vibration dynamic vibration absorber, centrifugal absorber, and friction damper, vehicle suspension system response.

Multi degrees Freedom System: Holzer's analysis for multimass and multi inertia systems, simple geared systems; Dunkerlay's methods, Stodla method.

Whirling of shafts: Whirling and its implications, whirling of light flexible shaft with a unbalance disc at the center, uniform shaft with and without unbalance - Rayleigh's method.

Continuous System: Free longitudinal vibrations, torsional vibrations of circular shaft, and transverse vibration of beam.

Practical Cum Tutorial

1. Determination of radius of gyration of a pendulum
2. Determination of radius of gyration of a bar using Bi-Filar suspension
3. Study of undamped free vibration of a equivalent spring mass system
4. Study of forced vibrations of equivalent spring mass system
5. Study of torsional vibrations (undamped) of single rotor shaft system
6. Study of free vibrations of two rotor system and to determine the natural frequency of vibration theoretically and experimentally
7. Study of damped torsional oscillations and determine the damping co-efficient
8. Verification of Dunkerley's rule
9. Study of forced lateral vibrations of the beam for different damping

Evaluation Scheme: 20% weightage for practical work.

Books Recommended

1. Rao S S, "*Mechanical Vibrations*", Pearson Education, Delhi (2004).
2. Roger A A, "*Fundamentals of Vibrations*", Amerind Publisher Company Private Limited, New Delhi (1999).
3. Srinivas P, "*Mechanical Vibration Analysis*", Tata McGraw Hill Company Limited, New Delhi (1990).
4. Mallik A K, "*Principles of Vibrations Control*", Affiliated East West Press Private Limited, New Delhi (2000).
5. Daniel J Inman, "*Engineering Vibration*", Prentice Hall, New Jersey (2001).

Departmental Electives

ME- 330

Unconventional Methods of Machining

[3 0 0 3]

Introduction: Mechanical Processes, Material removal theories, Fundamental principles, Process parameter characteristics, Metal removal rate analysis, Principles and Mechanism of Water jet machining, Abrasive jet machining, Ultrasonic machining.

Chemical and Electro-Chemical Machining: Introduction, Principles, Process parameters, Applications, limitations, Kinematics, Dynamics and Hydro-dynamics, Analysis of Material removal, Introduction to lithography.

Electric Discharge Machining: Basic Principles and Scheme Circuitry controls, Metal removal rate, Machining Accuracy Optimization, Selection of Tool Material, Dielectric, Analysis of the Process.

Laser Beam Machining & Electron Beam Machining: Introduction, Production of Laser, Machining by Laser and its other applications: Electrons Beam action, Process controls, and applications.

Special Methods: Plasma Arc machining and Ion Implantation. High Velocity Forming of Metals, Explosive forming principles and various applications.

Books Recommended

1. Mishra P K, *“Non Conventional Machining”* Narosa Publishing House, New Delhi (1997).
2. Panday P C and Shan H S, *“Modern Machining Processes”* 5th reprint, Tata Mc Graw Hill, New Delhi (1998).
3. Ghosh Amitabha and Malik A K *“Manufacturing Science”* East West Publication, New Delhi (1985).
4. Code No. 244 *“Non Traditional Machining Processes”* All India Council for Technical Education (CEP) Bangalore (October 1992).
5. Code No. 308 *“Advance Machining Process”* All India Council for Technical Education (CEP) Bangalore.

ME- 331

Design for Production

[3 0 0 3]

Product Design: Definition of product design, design by evolution, innovation and imitation, product life cycle, consumption cycle, types of products. Design process steps, morphology of design, relationship of innovation to design, management of research and development in the organization, role of technology transfer in innovation, problem solving and decision making techniques used in design, models used in design- physical and analytical, prototypes. Standardization, simplification and specialization in design, factors affecting product specifications and range, design for manufacturability, consideration of safety and reliability in design, economic analysis, time value of money, cost comparison, break-even analysis and cost benefit analysis. Role of value engineering, ergonomics and computers in design.

Ergonomics: Introduction, history of development, man-machine system and its components. Introduction to structure of the body- features of the human body, stress and strain, metabolism, measure of physiological functions- workload and energy consumption, biomechanics, types of movements of body members, strength and endurance, speed of movements. Applied anthropometry-types, use, principles in application, design of work surfaces and seat design. Visual displays for static information, visual displays of dynamic information, auditory, tactual and olfactory displays and controls. Effect of vibration, noise, temperature and illumination on performance.

Books Recommended

1. Karl T Ulrich and Steven D Eppinger, *“Product design and Development”*, McGraw-Hill Inc (2000).
2. George E Dieter, *“Engineering Design”*, McGraw-Hill Inc (2000).
3. R S Bridger, *“Introduction to Ergonomics”*, McGraw-Hill Inc (1995).
4. Mark S Sandeer and Ernest J Mc Cormick, *“Human Factors in Engineering and Design”*, McGraw-Hill Inc (1993).
5. Kelvin Otto and Kristen Wood, *“Product Design”*, Pearson Education, Delhi (2001).

ME-332

Solar Thermal Process

[3 0 0 3]

Solar Radiation: Solar radiation outside the earth’s atmosphere, solar radiation at the earth’s surface, instruments for measuring solar radiation and sunshine, solar radiation data, solar radiation geometry, solar radiation on tilted surfaces.

Solar Energy Collection: Flat – Plate collectors: Transmissivity of cover system, physical principles of conversion of solar radiation into heat, energy balance equation and collector efficiency, concentrating collectors: Focusing type, selective absorber coating.

Thermal Energy Storage: Scribble heat storage, latest heat storage, thermo-chemical heat storage.

Solar Water Heating Systems: Natural circulation water heater; (pressurized and non-pressurized) Forced circulation solar water heater, space heating and cooling.

Solar Crop Drying: Working principle: Open sun drying, direct solar drying, and indirect solar drying.

Solar Distillation and Solar Pond and other Applications: Working Principle, principle and description of solar pond and operational problem, collection – cum storage water heater, Green house, solar cooker, heating of biogas plant by solar energy.

Books Recommended

1. Sukhatme S P, *“Solar Energy: Principles of Thermal Collection and Storage”*, 2nd edition, Tata McGraw Hill, Delhi (1997).
2. Tiwari G N, *“Solar Energy: Fundamentals, Design, Modeling and Applications”*, 1st Edition, Narosa Publishing House, New Delhi (2003).
3. Rai G D, *“Non-Conventional Sources of Energy”*, 4th Edition, Khanna Publisher, Delhi (1999).
4. Agarwal M P, *“Solar Energy”* S Chand, New Delhi (1989).
5. Garg H P and Parkash J, *“Solar Energy: Fundamentals and Applications”*, Tata McGraw Hill, Delhi (2003).

ME-333

Advances in Metal Forming

[3 0 0 3]

Stress and strain analysis, yield conditions, stress strain relation in elastic and plastic deformations, hardening, formulations of elastic and plastic problems, methods of solution, slab method, slip line and extra-mium principles, applications of theory of plasticity to metal working operations like wire drawing, extrusion, rolling, forging, deep drawing, spinning etc. Friction in metal working, recent developments in technology and theory.

Books Recommended:

1. Harris J N, *“Mechanical Working of Metals: Theory and Practice”*, 1st Edition, Pergamon, New York (1983).
2. Mielnik E M, *“Metal Working Science and Engineering”*, McGraw Hill (1991).
3. Wagoner H Robernt, Chenot lean-Loup, *“Fundamentals of Metal Forming”*, Wiley Text Books (1996).
4. Proceedings of the Conference, *“Mechanical Working and Steel Processing 20th”*, Iron and Steel Society (1983).
5. Kumar S, *“Principles of Metal Working”*, Oxford and IBH Publishing Company, New Delhi (1985).

ME-334

Numerical Control for Machine Tool

[3 0 0 3]

Introduction: Basic concepts of manufacturing system and CAD/CAM. NC/CNC machine tools, NC machine tools-basic components, coordinate systems, features of NC machine tools. Computerized numerical control (CNC), tooling for NC machines-tool, presetting equipment, flexible tooling, tool length compensation, tool path graphics, NC motion control system, manual part programming, fixed/floating zero. block format and codes, computer assisted part programming. DNC and adaptive control, direct numerical control, adaptive control in machining system, combined DNC/CNC system.

Books Recommended

1. Zeid Ibrahim, *“CAD/CAM Theory and Practice”*, Tata McGraw Hill Publishing Company (1999).
2. Chris McMohan, *“CAD/CAM:Principles: Practice and Manufacturing Management”*, Pearson Education India (1998).
3. Groover M, *“Computer Aided Design and Manufacturing”*, Pearson Education India (2003).
4. Rao P N, *“CAD/CAM”*, Tata McGraw Hill Publishing Company (1999).
5. Bedworth D and Henderson M R, *“Computer Integrated Design and Manufacturing”*, Tata McGraw Hill Publishing Company (1998).

ME- 335

Tool Design

[3 0 0 3]

Tool Design Methods: Introduction, The Design Procedure, Drafting Practice, Drawing Layout.

Tool Making Practice: Introduction, tools of the toolmaker, hand finishing and polishing, screws and dowels, jig boring practice, punch and die manufacture, electrodischarge machining for cavity applications.

Tooling Materials and Heat Treatment: Introduction, properties of materials, ferrous tooling materials, nonmetallic tooling materials, factors affecting heat treatment, heat treatment and tool design.

Design of Cutting Tools: The basic requirements of a cutting tool, general considerations for metal cutting, design of single point cutting tools, milling cutters, drills and drilling, reamers taps, carbide tools.

Sheet Metal Dies: Blanking and piercing die construction, press work materials, strip layout, bending dies, forming dies, drawing operations, single and double action draw dies.

Principles of Tool Design for Forging, Extrusion and Dies Casting: Introduction, general principles.

Tool Design for Numerically Controlled machine Tools: Need for numerical control, fixture design for numerically controlled machine tools, cutting tools for numerical control, tool-holding methods for numerical control, automatic tool changers and tool positioners, tools presetting.

Books Recommended

1. Donaldson Cyril, Lecain George H, Goold V C, *“Tool Design”*, Tata McGraw Hill Publishing Company Limited, New Delhi (1993).
2. Battacharayya A and Ham L, *“Design of Cutting Tools”*, SME, Dearborn, Mich (1969).
3. Paquin J R, *“Die Design Fundamentals”*, The Industrial Press, New York (1962).
4. Wilson F W, *“Fundamentals of Tool Design”*, Prentice Hall, Englewood Cliffs, N J (1962).
5. Wilson F W, *“Numerical Control in Manufacturing”*, McGraw Hill, New York (1963).

ME- 336

Flexible Manufacturing System

[3 0 0 3]

Review of Computer Aided Design and Drafting (CADD): The design processes, advantages and applications of CAD, computer hardware system, computer programming languages, model storage and data structure, CADD software packages – AutoCAD, orthographic projections.

CAD/CAM Interface and Product Design: Rationale for CAD/CAM, Computer-Aided Manufacturing, Elements of CAM Systems, NC in CAM, Product Design and Development.

Machine Tool Control: Elements of the NC Systems, Types of Control Systems, NC Part Programming, Computer Aided Part Programming, Machining Centers.

Manufacturing Systems and Automation: Trends in Manufacturing Systems, system Defined, Classification of Manufacturing Systems, Leveling and balancing the manufacturing Systems.

Robotics and Automated Guided Vehicles: Definition Robotics, Terminology, Types of Robots, basic robot motion and their control, robot programming, Automated Guided Vehicles. Typical applications in manufacturing like in welding, assembly, material handling, spray painting etc.

Group Technology (G T): Part families, parts classification, machine group/cell, cad/cam and GT, applications.

Flexible Manufacturing Systems and Computer Integrated Manufacturing Systems: (FMS) (CIMS): Components of FMS, components of CIMS, applications. Hardware and software pertaining to FMS installations.

Books Recommended

1. Rao P N, Tewari N K and Kundra T K, *“Computer Aided Manufacturing”*, Tata McGraw Hill Publishing Company Limited, New Delhi (1993).
2. Rehg J A, *“Introduction to Robotics – A System Approach”*, Prentice Hall International, Englewood Cliffs, New Jerrey (1985).
3. Tercholz E, *“CAD/CAM Handbook”*, McGraw Hill, New York (1984).
4. Malcolm D R Jr, *“Robotics: An Introduction”*, Delmar Publishers Inc (1988).
5. McMahon C and Browne J, *“CAD CAM: From Principles to Practice”*, Addison –Wesley Publishing Company, New York (1993).

ME-530/ME-675*

Mechanics of Composite Materials

[3 0 0 3]

Introduction: Basic concepts and definitions, constituent materials, applications and fabrication process related to composite materials.

Macromechanics: Lamina stress-strain relation, anistropic behaviour, engineering contents, stiffness and compliance matrices, transformed matrices and invariants. Analysis of laminates,

classification of laminates, laminated beams. Laminated plates, theory of laminated plates with coupling, stiffness characteristics of related laminates, laminate compliances, lamina and laminate stresses and strains, and laminate engineering constants. Introduction to interlaminar stresses, laminate strength and failure analysis.

Micromechanics: Continuous fiber-reinforced lamina, prediction of elastic moduli by mechanics of material, elasticity and semi-empirical models and model for prediction of lamina strength. Discontinuous fiber-reinforced lamina, elastic moduli and stress-strain relationship.

Mechanical Testing: Measurement of constituents i.e., fiber and matrix, measurement of elastic moduli, viscoelastic and dynamic properties of composites.

Books Recommended

1. Jones R M, *"Mechanics of Composite Materials"*, Scripta Book Company (1975).
2. Herkovic C T, *"Mechanics of Fibres Composites"*, University of Virginia, John Wiley and Sons, Inc (1998).
3. Tsai Stephen W, *"Introduction to Composite Materials"*, Technomic Publishing Company Inc (1980).
4. Gibson R F, *"Principles of Composites Materials Mechanics"*, McGraw Hill International Edition, New York (1994).
5. Hyer M W, *"Stress analysis of Fiber-Reinforced Composites Materials"*, WCB McGraw Hill, Boston (1997).

ME- 430

Total Quality Management

[3 0 0 3]

Quality and Total Quality Management: Excellence in manufacturing/services, factors of excellence, and relevance of TQM.

Concept and definition of quality: Total quality control (TQC) and Total quality Management (TQM), salient features of TQC and TQM. Total Quality Management Models, benefits of TQM.

Just-in-Time (JIT): Definition: Elements, benefits, equipment layout for JIT system, Kanban system, MRP (Material Requirement Planning) vs JIT system, Waste elimination, workers involvement through JIT: JIT, cause and effect chain, JIT implementation.

Customer: Satisfaction, data collection and complain, redressal mechanisms.

Process Management: Factors affecting process management, Quality function deployment (QFD), Quality Assurance System.

Total Employees Involvement: Empowering employees: Team building; quality circles, Reward and Recognition; Education and Training, Suggestion schemes.

Problem solving: Defining problem, problem identification and solving process, QC tools.

Benchmarking: Definition, concept, process and types of benchmarking.

Quality Systems: Concept of quality system standards, Relevance and origin of ISO 9000, Benefits, Elements of ISO 9001, ISO 9002, ISO 9003.

Books Recommended

1. Besterfield and Besterfield, *"Total Quality Management"*, 2nd Edition, Pearson Education (Singapore) P Ltd, India (2001).
2. Sunder Raju, *"Total Quality Management A Primer"*, 3rd Edition, Tata McGraw Hill, Delhi (2001).
3. Zairi M, *"Total Quality Management for Engineers"*, 2nd Edition, Aditya Books, Delhi, (1995).
4. Hradesky J L, *"Total Quality Management Handbook"*, McGraw Hill (1994).

5. Dalela S and Saurabh, "A manual of ISO 9000 Quality System", 2nd Edition, S Chand & Company Ltd, Delhi (1999).

ME- 431

Operation Management

[3 0 0 3]

Operations Management: Introduction, Historical Evolution of Production and Operations Management, Trends in Operation Management, Production and Operations management as a Career, Operation strategies for competitive advantages, Productivity and Quality, Technology and Mechanization.

Production Planning and Control: Forecasting, Capacity Planning, Layout Planning, Location Analysis, Plant Layout and Materials Handling.

Product Design and Development: Steps involved in Product design and development, Factors affecting Project Design and Development like ergonomics, aesthetic, economic, technical. Case studies.

Materials Management and Inventory Control: Inventory concepts, Scope, function and objectives of Inventory, Inventory costs, Determination of E.O.Q., ERP, MRP-I, MRP-II, Just in time, Concept of Zero Inventory.

Quality Control: Meaning of Quality Control and its Impact, Functions of Quality Control, Introduction to SQC, Japanese Contribution to Quality Control, Managing Quality, Introductory Concept of Six Sigma, Introduction to ISO 9000 and 14000, Specific Case Studies.

MIS: Introduction to Management Information system, Steps involved in designing an MIS, Role and Application of Computers in MIS, Case studies.

Project Management: Project planning, Project scheduling models, Managing the project, Work breakdown structure, Progress reporting, Role of Human Behavior in project environment.

Books Recommended

1. Buffa and Sarin, "Modern Production / Operation Management", 8th Edition, John Wiley and Sons (1987).
2. Adam and Ebert, "Production and Operations Management", 5th Edition, Prentice Hall of India, New Delhi (2000).
3. Krajenski and Ritzman, "Operations Management Strategy and Analysis", 6th Edition, Pearson Education, New Delhi (2002).
4. Mazda Fraidoon, "Engineering Management", 3rd Reprint, Pearson Education (2000).
5. Besterfield, "Total Quality Management", Pearson Education (2003).

ME- 432

Non Conventional Energy

[3 0 0 3]

Wind Energy: Basic principle of wind energy conversion, wind data and energy estimation, site selection considerations, basic components of a WECS, classification of WECS system, application of wind energy.

Biomass Energy: Biomass conversion technologies, photosynthetic, biogas generation, factors affecting bio-digestion, classification of biogas plants with their advantages and disadvantages, types of biogas plants, constructional details of digesters, site selection for biogas plants, methods of obtaining energy from biomass.

Geothermal Energy: Nature of geothermal fields, types of geothermal sources. Advantages and disadvantages of geothermal energy over other energy forms, application of geothermal energy, geothermal energy prospects in India.

Energy from Ocean: Ocean thermal electric conversion, methods of ocean thermal electric power generation, energy from tides, basic principle of tidal power, components of tidal power plant, methods of utilization of tidal energy ocean waves and introduction and wave energy conversion devices.

Fuel Cell: Design and principle of operation of fuel cell, classification of fuel cells.

Magneto Hydrodynamic Power Generation: Principle of MHD power generation, types of MHD systems.

Thermo Electric Power: Basic principle of thermoelectric power generation, thermoelectric materials, selection of materials.

Thermionic Generation: Thermionic emission and work function, basic thermionic generator.

Hydrogen Energy: Hydrogen production, hydrogen storage and transportation, hydrogen as an alternative fuel for motor vehicles.

Books Recommended

1. Rai G D, *“Non-Conventional Energy Sources”*, 4th Edition, Khanna Publishers, Delhi (1999).
2. Rao S and Paruleka B B, *“Energy Technology”*, 1st Edition Khanna Publishers, Delhi (1999).
3. Abbasi S A and Abbasi Narsema, *“Renewable Energy Sources and their Environmental Impact”*, Prentice Hall of India Private Limited, New Delhi (2001).
4. Kothari, D.P, Singal, K.C. & Ranjan, Rakesh, *“Renewable Energy sources and Emerging Technologies”*, 1st Edition Prentice Hall of India (2008)

ME-531*

Lubrication and Wear

[3 0 0 3]

Introduction: Tribological consideration, Nature of Surfaces and their contact; physico-mechanical properties of surface layer, Geometrical properties of surfaces, method of studying surface, contact of smooth surface, contact of rough surfaces.

Friction and Wear: Role of friction laws of static friction, Causes of friction, Adhesion theory, Laws of rolling friction, friction of metals and non-metals, friction measurement. Definition of wear, mechanism of wear, factors effecting wear, wear measurement, wear of metals and nonmetals.

Lubrication and Lubricants: Introduction, dry friction, Boundary lubrication, hydrostatic and elasto hydrodynamic lubrication.

Functions of lubricants: Types of lubricants and their industrial uses, Properties of liquid and grease lubrications. Lubricant additives, general properties and selection.

Special Topics: Bearing design, selection of bearings and lubrications, Bearing maintenance, diagnostic maintenance of tribological components.

Books Recommended

1. O’Conner and Boyel, *“Standard Handbook of Lubrication Engineering”*, McGraw Hill Company, New York (1968).
2. Bharat Bhushan, *“Principles and Applications of Tribology”*, 1st edition, Wiley-Interscience (1999).
3. Raymond O Gunther, *“Lubrication”*, Bailey Bros and Swinten Limited (1971).
4. Rowe William Brian, *“Hydrostatic and Hybrid Bearing Design”*, Butter worth-Heinemann (1983).

5. Barwell P T, *“Bearing Systems, Principles and Practice”*, 1st Edition, Oxford University Press, New York (1980).

ME-532 * Industrial Safety and Environment

[3 0 0 3]

Safety: Meaning & need for safety. Relationship of safety with plant design, equipment design and work environment. Industrial accidents, their nature, types and causes. Assessment of accident costs; prevention of accidents. Industrial hazards, Hazard identification techniques, Accident investigation, reporting and analysis. Safety and economics, safety and productivity. Employees participation in safety. Safety legislation .

Environment: Environmental factors in industry. Effect of temperature, Illumination, humidity noise and vibrations on human body and mind.

Physiology of heat regulation. Thermal environment and its measurement. Thermal comfort. Indices of heat stress. Thermal limits for comfort, efficiency and freedom from health risk. Natural ventilation. Mechanical ventilation. Air conditioning Process ventilation. Control of heat exposures, control at source, insulation, and local exhaust ventilation. Control of radiant heat, dilution ventilation. Local relief.

Industrial Lighting: Purpose of lighting, benefits of good illumination. Phenomenon of lighting and safety. Lighting and the work. Sources and types of artificial lighting. Principles of good illumination. Recommended optimum standards of illumination. Design of lighting installation.

Noise and Vibrations: Continuous and impulse noise. The effect of noise on man. Noise measurement and evaluation of noise. Noise isolation. Noise absorption techniques. Silencers vibrations: Effect, measurement and control measures.

Measurement and mitigation of physical and mental "fatigue" Basics of environment design for improved efficiency and accuracy at work.

Books Recommended

1. Krishnan N V, *“Safety management in Industry”*, Jaico Publishing House, Delhi (1993).
2. Kocurek Dianna and Woodside Gayle, *“Environment, Safety, and Health Engineering”*, John Wiley and Sons, New York (1997).
3. McCormick J, *“Human Factors in Engineering and Design”*, Tata McGraw Hill Publishing Company Limited, New Delhi (1979).
4. Willie Hammer, Dennis Price, *“Occupational Safety Management and Engineering”*, 5th Ed., Pearson Education (2000).
5. David Goetsch, *“The Safety and Health Handbook”*, Pearson Education (1999).

ME- 533*

Cryogenics

[3 0 0 3]

Introduction: Historical review, application areas, properties of cryogenic fluids.

Cryogenic Liquefaction System: Refrigeration and liquefaction cycles, ideal cycle, actual liquefaction cycles.

Cryogenic Refrigeration Systems: Joule Thompson, striling, Gifford – McMahon, magnetic refrigeration system.

Air Separation System: Linde and Claude system for air liquefaction.

Components of cryogenic systems: Heat exchanges, expanders, compressors, storage dewars and transfer lines.

Books Recommended

1. Barron R F, *“Cryogenic Systems”*, Oxford (1983).

2. Jacobsen T R, *“Thermodynamics Properties of Cryogenic Fluids”*, Plenum, London (1997).
3. Thomas M, *“Cryogenic Engineering”*, (1997).
4. Heselden G G, *“Cryogenic Fundamentals”*, Academic Press, London (1971).
5. Flynn T M, *“Cryogenic Process Engineering”*, Plenum (1989).

ME- 534*

Power Plant Engineering

[3 0 0 3]

Introduction: Power plant, classification, steam power plant, gas turbine, based, I C Engine based, nuclear power based, hydropower.

Steam Power Plant: Components of steam power plant, carnot cycle, Rankine cycle, Different methods to improve the efficiency of steam power plant, regeneration, reheating of steam, regenerative feed water heating. Supercritical pressure cycle, cogeneration of power and process heat.

Combined cycle power generation: Binary vapour cycles, coupled cycles, gas turbine – steam turbine power plant, MHD – Steam power plant, thermionic steam power plant.

Fuels and Combustion: Various types of fuels, coal, fuel oil, natural and petroleum gas, synthetic fuels, biomass, combustion process, combustion equipments like cyclone furnace, fluidized bed combustion.

Steam Generators: Classification, fire tube boiler, water-tube boilers, economizers, super heaters, air preheater, deaerator, boiler blowdown, air handling system, electrostatic precipitators.

Steam Turbines: Types of turbines, Impulse and Reaction, compounding in turbine, pressure, velocity compounding.

Condensers: Direct contact condensers, surface condensers, cooling towers, cooling tower calculations.

Gas Turbine Power Plant: Components of gas turbine based power plant, open cycle and closed cycle, methods to increase the efficiency of gas turbine plant like intercooling, reheating and regeneration.

Hydro Power Plant: Classification of water turbines, construction and working of Pelton Francis and Kaplan turbines.

Economics of Power Generation: Load duration curves, power plant economics, location, Indian energy scenario.

Books Recommended

1. Wiesman J and Eckart R, *“Modern Power Plant Engineering”*, Prentice Hall, New Delhi (1985).
2. Nag P K, *“Power Plant Engineering”*, Tata McGraw Hill, New Delhi (1998).
3. Kostyuk A and Frolov V, *“Steam and Gas Turbines”*, Mir Publishers, Moscow (1988).
4. Aschner F S, *“Planning Fundamentals of Thermal Power Plants”*, John Wiley (1978).
5. Eastop T D and McConkey, *“Applied Thermodynamics”*, Longman Scientific and Technical (1986).

ME -535 /ME-677*

Finite Element Methods

[3 0 0 3]

Fundamentals of the Finite Element Method, discretization of the domain, one-two and three dimensional elements and interpolation functions, local and global coordinates, properties of interpolation functions, compatibility and completeness requirements, Assembly and boundary conditions; Formulation for FEM solutions. Application to solid mechanics, vibrations, plates and shell problems.

Books Recommended

1. Desai and Abel, *“Introduction to Finite Element Method”*, East West, CBS Delhi (1987).
2. Zienkiewicz O C, *“Finite Element Method”*, McGraw Hill (1989).
3. Krishnamurthy C J, *“Finite Element Method – Analysis Theory and Programming”*, Tata McGraw Hill (1994).
4. Bathe k J, *“Finite Element Procedures”*, Prentice Hall of India Private Limited, New Delhi, (1996).
5. Belegundu Ashok D and Chandrupatla T, *“Introduction to Finite Element Method”*, PHI Private Limited, New Delhi (2003).

ME- 536*

Experimental Stress Analysis

[3 0 0 3]

Basic Elasticity: Laws of stress transformation, principal stresses and principal planes. Cauchy’s stress quadric strain analysis, strain equations of transformation, stress-strain relationship.

Photo elasticity Method:

Two dimensional photoelasticity: Behaviour of light, Stress optics law, plane and circular polariscope, dark and light field arrangement, fringe multiplication, compensation techniques, commonly employed photo elastic materials.

Three dimensional photoelasticity: Newman’s strain optic relationship, stress freezing in model materials for three dimensional photoelasticity, shear difference method for stress separation.

Coating:

Birefringence coatings: sensitivity, reinforcing effects, thickness of birefringence coatings.

Brittle coatings: Introduction, coating stresses and failure theories, different types of crack patterns, crack detection, composition of brittle coatings, coating cure, influence of atmospheric conditions, effects of biaxial stress field.

Electric resistance strain gauge: Gauge construction and installation, temperature compensation, gauge sensitivities, gauge factor, corrections for transverse strain effects, factors effecting gauge relation, rosetters, Rosette analysis, potentiometer and whetstone’s bridge circuits for strain measurement.

Books Recommended

1. Dally J E and Rilley W P, *“Experimental Stress Analysis”*, 3rd Edition, McGraw Hill, New Delhi (1991).
2. Dove R C and Adams P H, *“Experimental Stress Analysis and Motion Measurement”*, McGraw Hill, New York (1978).
3. Holister C S, *“Experimental Stress Analysis”*, 5th Edition, Cambridge University Press (1987).
4. Dally J E and Rilley W P, *“Introduction to Photomechanics”*, Prentice Hall Inc, NJ (1981).
5. Mubeen A, *“Experimental Stress Analysis”*, 1st Edition Dhanpat Rai and Sons, New Delhi (1997).

ME- 433

Automobile Engineering

[3 0 0 3]

Introduction to Automobile: Importance, applications, job opportunities, classification, types of vehicles, Basic structure, general layout, hybrid vehicles.

Automotive Electric and Electronic Systems: Electric and electronics principles, systems, and circuits, automotive batteries, construction, and operation, starting system, charging system, operation and service, ignition system, electronic ignition and fuel control, engine management, electric vehicles.

Automotive Drive Trains: Clutches, manual and automotive transmission and transaxles, drive shafts, universal joints, drive axles.

Automotive Chassis: Suspension system, steering system, wheel alignment, brakes, wheels and tyres.

Maintenance and Trouble Shooting: Automobile performance, drivability, emissions and emission norms, noise and vibration, engine tuning, equipment for measuring various vehicle parameters such as bhp, a/f ratio, noise, vibration and emission, comfort and safety.

Recent advances in automobiles and automotive components.

Books Recommended

1. Crouse W H and Anglin D N, "*Automotive Mechanics*", McGraw Hill, 10th Edition, Singapore (1993).
2. Bosch, "*Automotive Handbook*", SAE Publication (2000).
3. Tom Denton, "*Automobile Electrical and Electronics Systems*", Butterworth-Heinemann (2003).
4. Layne Ken, "*Automotive Engine Performance: Tune up, Testing and Service*", Englewood Prentice Hall of India (1986).
5. Tom Denton, "*Advanced Automobile Fault Diagnosis*", Butterworth-Heinemann (2002).

ME- 630/ME-687*

System Dynamics & Control

[3 0 0 3]

Introduction to Physical System Dynamics

Modeling of Physical System Dynamics: A Unified Approach:

Physical systems, Introduction to Bond graphs, Ports, Bonds and Power;

Elements of Bond graphs, 1-port elements – resistor R, Stiffness C, and Inertia I, Source of Effort S_e and Flow S_f ; 2-port elements – Transformer TF and Gyrator GY, with modulation, Junction elements 1 and 0;

Causality: Causality for basic 1-port and multi-ports.

Derivation of System equations from Bond graphs in first order state space form.

Bond graph modeling of multi-energy systems:

Mechanical Systems, Translation and rotation (about a fixed axis), Electrical Systems, Electromechanical Systems, Fluid systems,

Transducer models – cylinder, rack and pinion, electromechanical transducers - motors, pumps – positive displacement and centrifugal pump, gear trains, etc.

Analysis of linear systems:

Free and forced response for first and second order systems, Undamped and damped oscillator, Derivation of Signal flow graphs from Bond graphs, Derivation of Transfer functions, Bode plots

State variable analysis:

State transition matrix, Characteristic equation, Eigen values and Eigen vectors, Their impact on system response, Similarity transformations and their properties, Controllability and Observability, Canonical forms: Controllable, Observable, Diagonal

Stability Criteria:

Routh-Hurwitz criterion, Liapunov stability criteria.

Controllers:

Pole-placement method, Proportional Integral and Derivative feedback

Simulation and case studies:

Computer simulation of Dynamic Systems using Bond graphs

Recommended Books

1. Karnopp, Margolis, Rosenberg, System Dynamics: Modeling and Simulation of Mechatronic Systems, Fourth Edition, Wiley (Higher education), 2005.
2. Karnopp, Margolis & Rosenberg, System Dynamics: A Unified Approach, Wiley, 1990.
3. Amalendu Mukherjee & R. Karmakar, Modeling & Simulation of Engineering Systems through Bond Graphs, Narosa, 2000.
4. Amalendu Mukherjee, Ranjit Karmakar and Arun Kumar Samantaray, Bond Graph in Modeling, Simulation and Fault Identification, I. K. International Publishing House Pvt. Ltd, 2006.
5. Eronini Umez-Eronini, System Dynamics & Control, Brooks/ Cole Publishing Company, 1999.
6. B. C. Kuo, Feedback Control Systems, Prentice Hall.
7. K. Ogata, Modern Control Engineering, Prentice Hall.
8. Bernard Friedland, Control Systems Design, McGraw-Hill.

ME- 631* Robotics: Mechanics and Control

[3 0 0 3]

Introduction to Robotics:

Kinematics and Dynamics of Robotic linkages (open ended type manipulators):

Frames, Transformations: Translation and rotation, Denavit-Hartenberg parameters,

Forward and Inverse Kinematics, Jacobian,

Dynamics: Equations of motion, Newton-Euler formulation

Sensors and actuators:

Strain gauge, resistive potentiometers, Tactile and force sensors, tachometers, LVDT, Piezo electric accelerometer, Hall effect sensors, Optical Encoders, Pneumatic and Hydraulic actuators, servo valves, DC motor, stepper motor, drives

Control of Manipulators:

Feedback control of II order Linear systems, Joint control, Trajectory control, Controllers, PID control

Recommended Books

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Addison-Wesley, 2005.
2. Tsuneo Yoshikawa, *Foundations of Robotics*, MIT Press, 1990.
3. Saeed B. Niku, *Introduction to Robotics: Analysis, Systems, Applications*, Pearson Education Inc., 2001
4. Spong M. W., and Vidyasagar M., *Robot Dynamics and Control*, John Wiley & Sons, 1989.
5. Murray R. M., et al, *A Mathematical Introduction to Robotic Manipulation*, CRC Press, 1994.
6. Waldron K. J., and Kinzel G. L., *Kinematics, Dynamics and Design of Machinery*, John Wiley & Sons, 2004.
7. Eronini Umez-Eronini, *System Dynamics & Control*, Brooks/ Cole Publishing Company, 1999.
8. Amalendu Mukherjee, Ranjit Karmakar and Arun Kumar Samantaray, *Bond Graph in Modeling, Simulation and Fault Identification*, I. K. International Publishing House Pvt. Ltd, 2006.

ME- 632*

Computational Fluid Dynamics

[3 0 0 3]

Review of basic fluid mechanics and the governing Navier-Stokes equations, Techniques for solution of PDEs – finite difference method, finite element method and finite volume method, Finite volume (FV) method in one-dimension, Differencing schemes, Steady and unsteady calculations, Boundary conditions, FV discretization in two and three dimensions, Simple algorithm and flow field calculations, variants of SIMPLE, Turbulence and turbulence modeling, illustrative flow computations, Commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.

Recommended Books:

1. S V Patankar, *Numerical Heat Transfer and Fluid Flow*, McGraw Hill, NY, (2005).
2. John Anderson, "*Computational Fluid Dynamics*", McGraw-Hill Publication, First edition (February 1, 1995).
3. W M Kays and M E Crawford, *Convective Heat and Mass Transfer*, Mc-Graw Hill, New York (1993)
4. F M White, *Viscous Fluid Flow* by, Mc-Graw Hill, New York, 2nd Ed. (1991).
5. Robert Siegel and John Howell, *Thermal radiation Heat Transfer*, 4th Edition, Taylor and Francis NY, (2002)

ME- 633*

Operations Research

[3 0 0 3]

Overview: Introduction, Definition, characteristics and scope of O.R., Objectives of O.R., Phases and models in O.R.

Linear Programming: Introduction, Concept of linear programming, Graphical method, Simplex method, Big M method, Dual simplex method, Two-phase method, Duality in linear programming.

Transportation Problem: Introduction, Mathematical models for T.P., Formulation and solution of balanced and unbalanced T.P., Transshipment models.

Assignment Models: Definition, Comparison with transportation model, Mathematical representation of assignment models, Formulation and solution of assignment models, Variations of the assignment problem and alternate optimal solutions.

Sequencing Models: Processing n jobs through two machines, processing n jobs through three machines, processing two jobs through m machines, processing n jobs through m machines, Travelling salesman problem.

Inventory Control: Purchase model with instantaneous replenishment and with and without shortages, Manufacturing model with and without shortages, Quantity discount.

Queueing Theory: Introduction, Terminologies of queueing system, Empirical queueing models.

Replacement Models: Replacement of items that deteriorate with time, Replacement of items that fail suddenly, Individual and group replacement.

Game Theory: Introduction and terminologies of game theory, games with pure and mixed strategies.

CPM and PERT: Basics steps in PERT and CPM, PERT and CPM computations, Cost analysis, Contracting and Updating, Resource Scheduling.

Books Recommended :

1. Panneerselvam R, "Operations Research", PHI, 2002.
2. Tulsian P.C., Pandey Vishal, "Quantitative Techniques", Pearson Education, 2002.
3. Wagner, "Principles of Operations Research", Prentice-Hall India, 2000.

Introduction. Chemical thermodynamics and chemical kinetics. Conservation equations for multi-component systems. Premixed systems - detonation and deflagration, laminar flames, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching turbulent pre-mixed flames. Non-premixed systems: laminar diffusion flame jet, droplet burning. Combustion of solids: drying, devolatilization and char combustion. Practical aspects of coal combustion. Review of combustion fundamentals. Gas-fired furnace combustion. Oil-fired furnace combustion. Gas turbine spray combustion. Combustion of solids. Industrial applications involving combustion. Burner design, testing and control. Emissions. Combustion safety.

Books Recommended:

1. Stephen R. Turns, *An Introduction to Combustion: Concepts and Applications*, 2nd Edition, Mc-Graw Hill, (2005).
2. Kenneth Kuan-yun Kuo, *Principals of Combustion*, John Wiley and Sons, NY (2005).
3. Charles E Baukal Jr., *Industrial Burners Hand Book*, CRC Press, Boca Raton, New York (2004).
4. Charles E Baukal Jr., *Heat Transfer in Industrial Combustion*, CRC Press, Boca Raton, New York Ed. (2005)
5. N H Afgan and J M Beer, *Heat Transfer in Flames*, Scripta Book Co., Washington D C (1974)

*These courses can be offered to UG and PG students as electives.

List of Departmental Electives

ME- 330	Unconventional Methods of Machining	3-0-0	3
ME- 331	Design for Production	3-0-0	3
ME- 332	Solar Thermal Process	3-0-0	3
ME- 333	Advances in Metal Forming	3-0-0	3
ME- 334	Numerical Control for Machine Tool	3-0-0	3
ME- 335	Tool Design	3-0-0	3
ME- 336	Flexible Manufacturing System	3-0-0	3
ME- 430	Total Quality Management	3-0-0	3
ME- 431	Operation Management	3-0-0	3
ME- 432	Non conventional Energy	3-0-0	3
ME- 433	Automobile Engineering	3-0-0	3
ME- 532	Industrial Safety and Environment		
ME- 533	Cryogenics	3-0-0	3
ME- 534	Power Plant Engineering	3-0-0	3
ME- 535	Finite Element Methods	3-0-0	3
ME- 536	Experimental Stress Analysis	3-0-0	3
ME- 530	Mechanics of Composite Materials	3-0-0	3
ME-630	System Dynamics & Control	3-0-0	3
ME-631	Robotics: Mechanics & Control	3-0-0	3
ME-632	Computational Fluid Dynamics	3-0-0	3
ME-633	Operations Research	3-0-0	3
ME- 634	Fundamentals of Combustion	3-0-0	3