Elective Courses
Department of Mechanical Engineering
Tezpur University

SNo	Course Code	Course Title	L-T-P-CH-CR
1	ME421	Computer Graphics and Solid Modeling	3-0-0-3-3
2	ME422	Optimization Methods in Engineering	3-0-0-3-3
3	ME425	Machine Tools and Machining	3-0-0-3-3
4	ME428	Finite Element Methods in Engineering	3-0-0-3-3
5	ME429	Gas Turbine and Compressor	3-0-0-3-3
6	ME434	Composite Materials	3-0-0-3-3
7	ME436	Combustion Engineering	3-0-0-3-3
8	ME439	Refrigeration and Air Conditioning	3-0-0-3-3
9	ME440	Advanced Mechanics of Solids	3-0-0-3-3
10	ME441	Elements of Computational Fluid Dynamics	3-0-0-3-3
11	ME442	Internal Combustion Engines	3-0-0-3-3
12	ME503	Mechanics of Composite Materials	3-1-0-4-4
13	ME504	Failure Analysis of Materials	3-0-0-3-3
14	ME505	Advanced Dynamics	3-1-0-4-4
15	ME506	Theory of Elasticity and Plasticity	3-0-0-3-3
16	ME507	Theory of Plates and Shells	3-0-0-3-3
17	ME508	Continuum Mechanics	3-0-0-3-3
18	ME511	Experimental Stress Analysis for Design	3-0-1-5-4
19	ME512	Theory of Plasticity	3-0-0-3-3
20	ME513	Introduction to Fracture Mechanics	3-0-0-3-3
21	ME521	Robotics	3-1-0-4-4
22	ME522	Quality Engineering	3-0-0-3-3
23	ME523	Non-Conventional Energy	3-0-0-3-3
24	ME525	Tribology	3-0-0-3-3
25	ME528	Energy Conservation and Waste Heat Recovery	3-0-0-3-3
26	ME531	Project Management	3-0-0-3-3
27	ME532	Power Plant Engineering	3-0-0-3-3
28	ME537	Applied Computational Methods	3-1-0-4-4
29	ME538	Computer-Aided-Design in Engineering	3-1-0-4-4
30	ME539	Optimization Techniques in Engineering	3-0-0-3-3
31	ME540	Evolutionary Algorithms for Optimum Design	3-0-0-3-3
32	ME542	Computational Fluid Dynamics	3-1-0-4-4
33	ME543	Compressible Flow	3-1-0-4-4
34	ME544	Turbulent Shear Flow	3-0-0-3-3
35	ME545	Viscous Fluid Flow	3-0-0-3-3
36	ME546	Fluid Transportation Systems	3-0-0-3-3
37	ME547	Two Phase Flow	3-0-0-3-3
38	ME549	Conduction and Radiation Heat Transfer	3-0-0-3-3
39	ME550	Heat Transfer Equipment Thermal Design	3-0-0-3-3
40	ME551	Renewable Fluid Power Technology	3-0-0-3-3
41	ME552	Renewable Thermal Power Technology	3-0-0-3-3
42	ME553	Refrigeration System and Component Design	3-0-0-3-3
43	ME572	Advanced Engineering Materials	3-0-0-3-3

44	ME573	Quality Science and Engineering	3-0-0-3-3
45	ME575	Advanced Materials for Design	3-0-0-3-3
46	ME579	Advanced Foundry Technology	3-0-0-3-3
47	ME580	Advanced Metal Joining Technology	3-0-0-3-3
48	ME581	Advanced Metal Forming Technology	3-0-0-3-3
49	ME582	Heat Treatment Technology	3-0-0-3-3
50	ME601	Automobile Engineering	3-0-0-3-3
51	ME603	Thermal power generation systems	3-0-0-3-3
52	ME605	Hybrid Electric Vehicles	3-0-0-3-3
53	ME606	Stability Problems in Applied Mechanics	3-1-0-4-4
54	ME607	Soft Computing Technique in Engineering	3-0-0-3-3
55	ME608	Mechatronics and Industrial Automation	3-0-0-3-3
56	ME609	Design of Internal Combustion Engine	3-0-0-3-3
57	ME610	Kinematics and Dynamics of Internal Combustion Engine	3-0-0-3-3
58	ME622	Communication Skills for Scientists and Engineers	2-1-0-3-3

Syllabus

ME421: Computer Graphics and Solid Modelling **L-T-P-CH-CR: 3-0-0-3-3**

Interaction devices and techniques;

Geometrical Transformations, viewing in 3D, Modelling and object hierarchy;

Raster Algorithms, Display representation of 3D shapes, rendering of surfaces and solids, hidden lines, edges and surface removal;

Shading models and shadows;

Constructive solid Geometry, B-Rep, Wire frame models.

ME422: Optimization Methods in Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Classical optimization methods, unconstrained minimization;

Univariate, conjugate direction, gradient and variable metric methods, constrained minimization;

Feasible direction and projections;

Integer and Geometric programming;

Genetic Algorithms; Simulated Annealing Techniques;

Design Applications.

Textbooks:

1. K. Deb. Optimization for Engineering Design: Algorithms and Examples. 2005.

2. J.S. Arora. Introduction to Optimum Design. Elsevier, 2/e, 2004.

ME425: Machine Tool and Machining **L-T-P-CH-CR: 3-0-0-3-3**

Machining process and principles: types of metal cutting, mechanics of metal cutting, chip formation and types of chip produced, chip thickness ratio and shear angle.
Machinability: criteria for machinability, variables affecting machinability, tests to determine machinability.
Cutting tool: tool geometry, tool materials and properties, classifications, tool wear and tool life, Thermal aspects of machining.
Cutting forces and power in machining, measurements of cutting forces.
Cutting fluids.
Economics of machining.
Classification and specification of machine tools, Kinematics and structures of conventional machine tools
Practical machining operations: lathe, turning, milling, shaping, slotting, planing, drilling, boring, broaching, grinding, thread rolling and gear cutting machines.
Finishing operations
Machine tool automation, CNC machines and programming, Various semi-automatic and automatic lathes
Unconventional or advanced machining methods: electro-chemical, electro-discharge, ultrasonic, Laser, electron beam and water jet machining.

ME428: Finite Element Methods in Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Introduction to FE method: The basic concept of FEM, Historical background, Need of FEM, Applications, advantages, and limitations of FEM, Real-life application of FEM with PPT presentation.
Analysis of 1D problem: Different approaches in FEM: General steps of FE method, Direct approach, Direct formulation of an axial rod problem, Solving of problems using the direct approach.
Analysis of Truss: Derivation of the element stiffness matrix of truss element, Global stiffness matrix, Solution of truss problems.
Finite elements and Interpolation function (IF): Shape functions, Pascal pyramid for polynomial, Line elements, Lagrangian form of IF, Length coordinate for higher-order element, Finite element formulation of bar and beam elements; Derivation of the element stiffness matrix for bar and beam elements, Solution of bar and beam problems.

Analysis of 2D problems: Triangular elements, Area coordinates, Shape function of the triangular element, Rectangular elements, Shape function of the rectangular element, Serendipity approach, Isoparametric formulation, Coordinate transformation, Solution of triangular and rectangular elements.
Introduction to the calculus of variation: Calculus of variation, Functional, Exetremization of functional, Properties of variational operation, Variational form from a differential equation, Solution of problems.
Approximate methods of analysis: Different types of approximate methods, Ritz method, Method of weighted residual, Galerkin's method, Solving problems using Ritz and Galerkin method.
Numerical integration: Need of numerical integration in FEM, Gauss Quadrature in 1D and 2D, Solving problems using Gauss Quadrature rule.
Assignments: Modelling and analysis of structural components using the commercial FE software package.

Textbooks:
1. Desai YM, Eldho TI, and Shah AH. Finite Element Method with Applications in Engineering, Pearson, 2019
2. Dixit US. Finite Element Methods for Engineers, Cengage Learning, 2018.

References:
1. Seshu P. Textbook of Finite Element Analysis, Prentice-Hall India, 2014.
2. Chandrupatla TR and Belegundu AD. Introduction to Finite Elements in Engineering, Pearson, 4t ed., 2019.
3. Huebner KH, Dewhirst, DL, Smith DE and Byrom TG. The Finite Element Method for Engineers, Wiley-Interscience, 4th ed., 2001.
4. Hutton DC. Fundamentals of Finite Element Analysis, Tata McGraw-Hill, 2005.
5. Reddy JN. An introduction to the Finite Element Method, Tata McGraw-Hill, 2006.

ME429: Gas Turbine and Compressor **L-T-P-CH-CR: 3-0-0-3-3**

Introduction - Development, classification and field of application of gas turbines.
Gas Turbine Cycle - Ideal and actual cycles; multi-stage compression; reheating, regeneration, combined and cogeneration.
Energy Transfer and Fluid Flow Characteristics - Energy transfer between fluid and rotor; axi-symmetric flow in compressors and gas turbines.
Centrifugal Compressors **-** Principles of operation; compressor losses; adiabatic efficiency; slip factor; pressure coefficient; power unit; design consideration for impeller and diffuser systems; performance characteristics.
Axial Flow Compressors - Elementary theory; vortex theory; degree of reaction; simple design; elementary air-foil theory; isolated airfoil and cascade theory; three dimensional flow; stages; stage efficiency and overall efficiency; performance characteristics.
Turbines - Axial flow and radial flow turbines; impulse and reaction turbines; fundamental relations and velocity triangles; elementary vortex theory; limiting factors in turbine design; application of airfoil theory to the study of flow through turbine blades; aerodynamic and thermodynamic design considerations; blade materials; blade attachments and blade cooling.
Gas Turbine Power Plants - Fuel and fuel feed systems; combustion systems-design considerations and flame stabilization; regenerator types and design; gas turbine power; plant performance and matching; applications.

Textbooks
1. Cohen and Rogers. Gas Turbine Theory (Longman, 4/e, 1996)
2. Dixon, S.L. Fluid Mechanics, Thermodynamics of Turbomachinery (Pergamon Press, 5/e, 2005).

References
1. Vincent, Theory & Design of Gas Turbine and Jet Engines (McGraw Hill, 1950)
2. Gas Turbine Principles and Practice (Cox Newnes, 1955)
3. Introduction to the Gas Turbine (Shepherd Constable, 1960)
4. Zucrow, Jet Propulsion and Gas Turbine (John Wiley, 1951)

ME428: Combustion Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Introduction: Historical perspective – fuels and combustion technology. Types and general characteristics of fuels. Fuel Analysis - proximate and ultimate analysis. Moisture and heating value determination – gross and net heating values – calorimetry, DuLong's formula for HV estimation, Flue gas analysis – Orsat apparatus.

Thermodynamics and kinetics of combustion: Properties of mixture; combustion stoichiometry; chemical energy; chemical equilibrium; properties of combustion products. First law combustion calculations – adiabatic flame temperature (analytical and graphical methods); second law analysis. Chemical Kinetics-Elementary reactions, chain reactions, preignition kinetics; global reactions; kinetics; reaction at solid surface.

Combustion of solid fuels: Drying; devolatilization; char combustion. Fixed bed combustion; suspension burning; fluidized bed combustion.

Combustion of liquid and gaseous fuels: Spray formation and droplet behaviour - oil fired furnace combustion - gas turbine spray combustion – direct and indirect Injection combustion in IC engines. Energy balance and furnace efficiency; gas burner types; pulse combustion furnace. Premixed charge engine combustion. Detonation of gaseous mixtures.

Emission control: Methods of Emission Control-Exhaust Gas Recirculation in IC Engines, Catalytic Converters, Electrostatic Precipitators, secondary air injection.

Textbooks and references

1. Kuo, K.K., Principles of Combustion, 2nd Edition, John Wiley and Sons, Inc., 2005
2. Kenneth W.Ragland, Kenneth M.Bryden, Combustion Engineering,2nd Ed, CRC Press,Taylor & Francis Group,2011
3. Borman, G.L. and Ragland, K.W., Combustion Enginnering, McGrawHill International Editions, 1998.
4. Samir Sarkar, Fuels and Combustion, 2nd Edition, Orient Longman, 1990.

ME434: Composite Materials **L-T-P-CH-CR: 3-0-0-3-3**

UNIT I Introduction: Introduction and overview of composite materials and their need, Enhancement of properties, classification of composites, Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Application of composites.

UNIT II Reinforcements Materials: Metallic, Polymer, Ceramic and Composite fibres, Whiskers and Particulates, Nano-fillers used in polymer composites, Reinforcement fibres, Woven fabrics and Nonwoven random mats. Course Code Course Name Lecture Tutorial Practical Credit ME 434 COMPOSITE MATERIALS 3 0 0 3 Types of matrix: Commonly used Matrices (Metal matrix, Polymer matrix, Ceramic matrix, Intermetallic matrix, Carbon-Carbon composites), Basic Requirements in Selection of constituents.

UNIT III Production techniques and Properties: Processing of cast composites - XD process, Spray processes (Osprey Process, Rapid solidification processing), In-situ Dispersion Processes (Stir-casting & Compo casting, Screw extrusion), Liquidmetal impregnation technique (Squeeze casting, Pressure infiltration, Lanxide process). Hand lay-up processes – Spray up processes, Compression moulding, Reinforced reaction injection moulding, Resin transfer moulding, Pultrusion, Filament winding, Injection moulding.

UNIT IV Mechanics of Composite Materials: Continuous fibres – iso-stress and iso-strain conditions, discontinuous fibres, Nature of stress vs. strain curves for different composite materials. Mechanical Properties: Mechanical testing of composites – tensile, flexure (3 point and 4 point bend tests), interfacial tests of laminates; Modes of fracture; Toughening mechanisms in composites.

UNIT V Recent developments in Composites: Self healing composites, Molecular composites, Micro and Nanocomposites, Biocomposites, Left handed composites, Stiffer than stiff composites, Carbon / carbon composites (Advantages and limitations of carbon matrix).

Text books:

1. Chawla K.K., Composite materials, Springer, New York, 1998.

Reference books:

1. Mathews F.L. and Rawlings R.D., Composite materials: Engineering and Science, Chapman and Hall, London, England, 1st edition, 1994.
2. Strong A.B., Fundamentals of Composite Manufacturing, SME, 1989.
3. Sharma S.C., Composite materials, Narosa Publications, 2000.
4. Mallick, P.K, Composite Materials Technology: Process and Properties, Hanser, New York, 1990.

ME439: Refrigeration and Air-Conditioning **L-T-P-CH-CR: 3-0-0-3-3**

Vapour-compression cycles; Absorption refrigeration; Vapour-compression-system analysis; Air-Craft refrigeration cycle; Multi-pressure systems; Refrigerants; Condensers and evaporators; Compressors; Expansion devices, Psychrometry, Psychrometric Processes; Heating- and cooling-load calculations; Air-conditioning systems; Fan and duct systems; Pumps and pumping; Cooling and dehumidifying coils; Air-conditioning controls; Heat pumps; Cooling towers and evaporative condensers.

Textbooks

1. Stoecker, W.F and Jones, J.W., Refrigeration and Air Conditioning (McGraw-Hill International Editions, 3/e, 1986.
2. Threkeld, J.L. Thermal Environmental Engineering (Prentice Hall Inc, 2/e., 1970).

References

1. Arora, C.P. Refrigeration and Air Conditioning (Tata McGraw-Hill, 2/e, 2000).
2. Air conditioning Design Handbook (Carrier Corpn, McGraw Hill, 1965)
3. ASHRAE Handbooks (ASHRAE, 2007)

ME440: Advanced Mechanics of Solids **L-T-P-CH-CR: 3-0-0-3-3**

Analysis of stress: Introduction, Cauchy's formula, Principal stress, Stress invariants, 3D Mohr's circle, Octahedral stresses, Hydrostatic and deviatoric stress, Differential equations of equilibrium in rectangular and cylindrical coordinate, Stress boundary conditions, Plane stress and Plane stress Problems, Airy's stress function.
Analysis of strain: Introduction, Definitions of normal and shear strain, Principal strain, Strain invariants, Plane strain in rectangular and polar coordinates, Compatibility conditions.
Generalized Hooke's law and theories of failure
Energy Methods: Introduction, Principal of superposition, Elastic strain energy and complementary energy, Reciprocal relations, Maxwell-Betti theorem, Castigliano's theorem, Virtual work principal, Statically indeterminate structures, Kirchoff's theorem.
Bending of beams: Bending of symmetric and unsymmetrical beams, Curved beam, Shear stresses in beams, shear center.
Torsion: Torsion of circular and non-circular sections;
Axisymmetric Problems: Thick and thin walled cylinders, Composites tubes, Rotating disks and cylinders
Elastic Stability: Euler's buckling load, Eigenvalue problem.

Textbooks:

1. Srinath L.S., *"Advanced Mechanics of Solids"* 2nd Edition, TMH Publishing Co. Ltd. New Delhi

References:

1. Budynas, R.G., "Advanced Strength and applied stress analysis" 2nd Edition, McGraw Hill Publishing Co.

2. Boresi, A.P., Schmidt, R.J., "Advanced mechanics of materials" 6th Edition, John Willey & Sons Inc.

3. Raymond, P., "Solid Mechanics in Engineering" 1st Edition, John Willey & Sons.

ME441: Elements of Computational Fluid Dynamics **L-T-P-CH-CR: 3-0-0-3-3**

General form of a conservation law; The Navier-Stokes (NS) equation; Mathematical nature of PDE's and flow equations. Basic Discretization techniques-Finite Difference Method (FDM), Integration methods for systems of ODE's, Linear Solver, Accuracy, Consistency; Stability; Convergence; Fourier or von Neumann stability analysis; Modified equation; Application of FDM to wave, Heat, Laplace and Burgers equations, Introduction to Finite Volume

Method on structured grids, Numerical solution of the Euler equations, Mathematical formulation of the system of Euler equations; Numerical solution of the incompressible Navier-Stokes equations.

ME442: Interal Combustion Engine **L-T-P-CH-CR: 3-0-0-3-3**

Unit 1: Introduction: Basic components and terminology, classification and application of IC engines, working of two- and four-stroke engines. SI and CI engine components and their working, engine design and operating parameters and their effects on engine performance, mean effective pressure, efficiency and specific fuel consumption. **(3 lectures)**

Unit 2: Fuel Air Cycles and Actual Cycles: Assumptions for fuel–air cycles, Reasons for variation of specific heats of gases, change of internal energy and enthalpy during a process with variable specific heats, isentropic expansion with variable specific heats, effect of variable specific heats on Otto, Diesel and Dual cycle, dissociation, comparison of air standard and fuel air cycles, effect of operating variables, comparison of air standard and actual cycles, effect of time loss, heat loss and exhaust loss in Petrol and Diesel engines, Pressure-crank angle diagram, valve and port timing diagrams. **(5 lectures)**

Unit 3: Combustion stoichiometry: Combustion equations, stoichiometric air fuel ratio, enthalpy of formation, adiabatic flame temperature, determination of calorific values of fuels. Calorimeters. **(5 lectures)**

Unit 4: Fuels and its supply system for SI and CI engine: Important qualities of IC engine fuels, rating of fuels, Carburetion, mixture requirement for different loads and speeds, carburetor and its working, Injection systems in CI engine. Nozzles and spray formation. **(4 lectures)**

Unit 5: Ignition and Governing System: Battery and magneto ignition system, spark plug, firing order, quality, quantity. Governing systems. **(3 lectures)**

Unit 6: Supercharging: Need for supercharging, Effect of supercharging, types of supercharger, methods of supercharging, thermodynamic analysis of supercharged engine cycle, limitations of supercharging, turbocharging. **(4 lectures)**

Unit 7: Combustion in SI and CI Engines: Stages of combustion in SI engines, abnormal combustion and knocking in SI engines, factors affecting knocking, effects of knocking, control of knocking, combustion chambers for SI engines, Stages of combustion in CI engines, detonation in C.I. engines, factors affecting detonation, controlling detonation, combustion chamber for SI and CI engine. (**4 lectures)**

Unit 8: Engine Lubrication and Cooling: Lubrication of engine components, Lubrication system – wet sump and dry sump, crankcase ventilation, Types of cooling systems – liquid and air cooled, comparison of liquid and air cooled systems. **(3 lectures)**

Unit 9: Measurement and Testing of IC engines: Measurement of indicated power, brake power, fuel consumption and emission, Measurement of friction power, calculation of brake thermal efficiency, brake power and brake specific fuel consumption, heat balance sheet of IC Engines. **(3 lectures)**

Unit 10: Engine Emission and their control: Air pollution due to IC engine emissions, Euro I to VI norms, BS VI norms. Formation of NOx, HC, CO and particulate emissions. Methods of controlling emissions; Catalytic convertors; particulate traps. Exhaust Gas Recirculation. Modern concepts of HCCI and GDI engines. **(3 lectures)**

Unit 11: Alternative Fuels: Alcohol, Hydrogen, Natural Gas, LPG, CNG, Biodiesel, batteries, fuel cell etc. and their behavior in engines. **(2 lectures)**

ME503: Mechanics of Composite Materials **L-T-P-CH-CR: 3-1-0-4-4**

Introduction - classifications, terminologies, manufacturing processes and applications of composite materials;

Macro-mechanical behavior of lamina - stress-strain relations, engineering constants for orthotropic materials, transformation of stress and strain, strength and stiffness of lamina, biaxial strength theories;

Micro-mechanical behavior of lamina – volume and mass fractions;

Macro-mechanical behavior of laminates – single-layered configurations, symmetric laminates, anti-symmetric laminates, strength of laminates;

Hygro-thermal analysis of lamina and laminates;

Design of laminates – symmetric, cross-ply, angle-ply and anti-symmetric laminates;

Failure analysis – failure criteria and failure modes, buckling and vibration of laminated beams, plates and shells;

Assignment and mini-project.

Textbooks

1. Daniel, I.M. and Ishai, O. *Engineering Mechanics of Composite materials* (Oxford University Press, 2005)
2. Jones, R.M. *Mechanics of Composite Materials* (Taylor & Francis, 1999)

References

1. Agarwal, B.D., Broutman, L.J. and Chandrashekhara, K. *Analysis and Performance of Fiber Composites* (John Willey &Sons, 2006)
2. Kaw, A.K. *Mechanics of Composite Materials* (Taylor & Francis, 2006)
3. Reddy, J.N. Mechanics of Laminated Composite Plates (CRC Press, 1997)

ME504: Failure Analysis of Materials **L-T-P-CH-CR: 3-0-0-3-3**

Introduction, common causes of failure, failure investigation, principle of failure analysis;

Fracture mechanics – energy approach and stress intensity factor approach to linear elastic fracture mechanics, concept of crack tip opening displacement and J-integral fracture criteria, mechanisms of fracture, evaluation of fracture toughness, fracture in composite materials, computational fracture mechanics analysis, fracture mechanics in nano materials and structures;

Creep - stress-tiMEtemperature relations, creep curve;

Fatigue - stresses in cyclic loading, fatigue testing, S-N curves and endurance limit, mechanisms of fatigue crack initiation and propagation, influence of stress concentration on fatigue strength, notch sensitivity, factors influencing fatigue behavior, prevention of fatigue failure;

Assignment and mini-project.

Textbooks

1. Kumar, P. *Elements of Fracture Mechanics* (McGraw-Hill, 2009)
2. Anderson, T.L. Fracture Mechanics: Fundamentals and Applications (CRC Press, 2004)

References

1. Bruck, D. Elementary Engineering Fracture Mechanics (Springer, 1986)
2. Barson, J.M. and Rolfe, S.T. *Fracture and Fatigue Control in Structures* (Butterworth-Heinemann, 1999)
3. Dieter, G. *Mechanical Metallurgy* (McGraw-Hill, 1986)
4. Calister, W.D. *Material Science and Engineering: An Introduction* (John Wiley & sons, 2009)
5. Gdoutos, E.E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

ME505: Advanced Dynamics **L-T-P-CH-CR: 3-1-0-4-4**

Newton and Euler equations of motion for constrained systems;

D'Alembert's principle, Lagrange's equations, Hamilton's equations;

Rigid body kinematics and dynamics;

Differential approaches for equations of motion;

Integral approach for equations of motion - Hamilton's principle, Boltzmann-Hamel equation;

Stability analysis of dynamic systems;

Numerical solutions of nonlinear algebraic and differential equations governing the behaviour of multiple degree of freedom systems;

Computer simulation of multi-body dynamic systems;

Assignment and mini-project.

Textbooks
1. Meirovitch, L.M. *Methods of Analytical Dynamics* (McGraw-Hill, 1988)
2. Baruh, H. *Analytical Dynamics* (McGraw-Hill, 1999)

References
1. Greenwood, D.T. *Principles of Dynamics* (Prentice Hall, 1988)
2. Shabana, A.A. *Computational Dynamics* (John Wiley & Sons, 2010)

ME506: Theory of Elasticity and Plasticity **L-T-P-CH-CR: 3-0-0-3-3**

Basic elasticity - cartesian tensor, three dimensional stress and strain systems, Navier's equations, Airy's stress function, Mohr's circle for three-dimensional stress and strain systems, viscoelasticity;

Torsion - torsion of noncircular bars, elastic analysis, membrane analogy;

Introduction to plasticity - mechanical behaviour in the plastic range, fundamentals of plasticity theory, solution of elastoplastic problem, Bausschinger effect-yield locus, yield surface;

Yield criteria and flow rules - Tresca theory and von Mises yield criterion, their geometrical representation, experimental evidence for the criteria;

Slip line field theory – two-dimensional plasticity, slip lines, basic equations, Hencky's first theorem, Geiringer's velocity equation, application of slip line field theory to plane strain problems;

Application to metal forming, plastic analysis of structures;

Assignment and mini-project.

Textbooks
1. Timoshenko, S.P. and Goodier, J.N. *Theory of Elasticity* (McGraw-Hill, 1970)
2. Chakroborty, J. *Theory of Plasticity* (McGraw Hill, 1987)

References
1. Sokolnikoff, I.S. *Mathematical Theory of Elasticity* (McGraw-Hill, 1957)
2. Khan, A. and Huang, S. *Continuum Theory of Plasticity* (Wiley, 1995)

ME507: Theory of Plates and Shells **L-T-P-CH-CR: 3-0-0-3-3**

Definition of plate and shells; Small deflections of transversely loaded isotropic thin plates; Equations and boundary conditions for thin rectangular and circular plates; Different types of supports associated with plate and shells; Shell behaviour, shell surfaces and characteristics, classifications of shells, equilibrium equations in curvilinear coordinates, force displacement relations; Moment theory; Rotationally symmetric shells; Shallow shell theory; Assignment and mini-project.

Textbooks
1. Timoshenko, S. and Woinowsky-Krieger, S. *Theory of plates and shells* (McGraw-Hill, 1959)
2. Ugural, A.C. *Stress in Plates and Shells* (McGraw-Hill, 1998)

ME508: Continuum Mechanics **L-T-P-CH-CR: 3-0-0-3-3**

Concept of continuum mechanics, mathematical preliminaries related to continuum mechanics;

Kinematics – motion of a continuum, displacement vector, deformation and deformable bodies, deformation gradient, strain tensor, equation of continuity, polar decomposition, volumetric and deviatoric strains, transformation of tensor, plane strain deformation;

Kinetics – traction boundary conditions, stress tensor, transformation of stress tensor, deviatoric stress, von Mises stress, balance of energy, entropy inequality;

Constitutive relations for various elastic materials such as thermoelastic material, isotropic thermoelastic material, transversely isotropic thermoelastic material, orthotropic thermoelastic material, incompressible elastic material, thermoviscoelastic material;

Applications to engineering problems such as torsion of a circular cylinder, bending of beams, expansion in pressure vessels, fluid flow between over plates and in circular pipes;

Assignment and mini-project.

Textbooks

1. Lai, W.M., Krempl, E. and Rubin, D. *Introduction to Continuum Mechanics* (Elsevier, 1996)
2. Gurtin, M.E. *An Introduction to Continuum Mechanics* (Academic Press, 1981)

References

1. Batra, R.C. *Elements of Continuum Mechanics* (AIAA, 2005)
2. Dill, E.H. *Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity* (CRC Press, 2006)
3. Fung, Y.-C. *A First Course in Continuum Mechanics* (Prentice-Hall, 1977)
4. Mase, G.T. *Continuum Mechanics for Engineers* (CRC Press, 1999)

ME511: Experimental Stress Analysis for Design **L-T-P-CH-CR: 3-1-0-5-4**

Review of Stress and Strain Analysis: Stress-strain relations and general equations of elasticity; Strain Measuring Devices: Various types of strain gauges, Electrical resistance strain gauges: gauge factor, types, gauge materials, backing materials, adhesives, protective coatings, bonding of strain gauges, lead wires and connections, Semiconductor strain gauges; Performance of Strain Gauges: Temperature compensation, transverse sensitivity, gauge length, response, excitation level, stability; Strain gauge circuits, recording instruments for static and dynamic applications, strain gauge rosettes analysis, stress gauge; Photoelasticity: Theory of photoelasticity, analysis techniques, three dimensional photoelasticity; Brittle coating methods of strain indication; Introduction to Moiré fringe technique; Residual Stress Analysis: Analytical and numerical solution of residual stresses in metal working processes (autofrettage, welding etc.), Experimental methods for assessing residual stresses: Sachsboring, X-ray diffraction, neutron diffraction and hole drilling method, inference of residual stresses from microhardness test.

Textbooks

1. Dove R.C. and Adams P. H. Experimental Stress Analysis (McGraw Hill, 1992)
2. Dally J.W. and Riley W.F. Experimental Stress Analysis (McGraw-Hill Inc., New York, 1998)
3. Srinath, L.S. and Raghavan M.R. Experimental Stress Analysis (Tata McGraw-Hill, 1998).

References

1. Freddi A. Olmi G. and Cristofolini L. Experimental Stress Analysis for Materials and Structures (Springer, Switzerland, 2015)
2. DTimoshenko S.P. and Goodier J.N. Theory of elasticit, (McGraw-Hill International Editions, 1970)
3. Fung, Y.-C. *A First Course in Continuum Mechanics* (Prentice-Hall, 1977)Sharpe W.N. Handbook of Experimental Solid Mechanics (Springer, 2008)
4. Noyan I.C. and Cohen J.B. Residual Stress (Springer, 1987)
5. Kandil F.A., Lord J.D., Fry A.T. and Grant P.V. A review of residual stress measurement methods A guide to technique selection (NPL Report MATC(A)04, February 2001, NPL
6. Kamal S.M. Borsaikia A. and Dixit U.S. Experimental assessment of residual stresses induced by the thermal autofrettage of thick-walled cylinders, Journal of Strain Analysis, Vol. 51(2), pp 144−160, 2016.

ME512: Theory of Plasticity **L-T-P-CH-CR: 3-0-0-3-3**

Stresses and Strain: Stress and strain behavior of materials, plastic and tangent modulus, strain hardening, plastic instability in tensile test, empirical stress-strain equations, effect of pressure, strain-rate and temperature. Analysis of stress tensor, eigenvalues, decomposition of stress tensor into deviatoric and hydrostatic components, octahedral stresses. Analysis of strain and strain-rates. Stress equilibrium and virtual work, objective stress rates. The criteria of

yielding. Isotropic and anisotropic hardening. Rules of plastic flow: Levy-Mises and Prandtl-Reuss equations. Hill's 1948 and 1979 yield criteria for anisotropic yielding. Anisotropic flow rule. Upper bound and lower bound theorems with a few applications. Axisymmetric elastic-plastic problems: Hydraulic autofrettage, Swage autofrettage and Thermal autofrettage; Expansion of hole in a plate. Plane stress elastic-plastic problems: Bending of beam. Indentation problem: by upper bound and cavity method. Dynamics Elasto-plastic problems: Longitudinal stress wave propagation in a rod, Taylor rod problem. Introduction to Updated Lagrangian and Eulerian formulations.

Textbooks

1. Dixit P.M. and Dixit U.S. Plasticity: Fundamentals and Applications (CRC Press, 2015)
2. Chakrabarty J. Theory of Plasticity (Elsevier Butterworth-Heinemann, 2006)

References

1. Dixit P.M. and Dixit U.S. Modeling of Metal Forming and Machining Processes by Finite Element and Soft Computing Methods (Springer, 2008)
2. Rees D.W.A. Basic Engineering Plasticity (Elsevier Butterworth-Heinemann, 2006)
3. Lal G.K. and Reddy N.V. Introduction to Engineering Plasticity (Narosa, 2009)
4. Kamal S.M. and Dixit U.S. Feasibility study of thermal autofrettage of thick-walled cylinders, ASME Journal of Pressure Vessel and Technology, Vol. 137(6), pp. 061207-1−061207-18, 2015.

ME513: Introduction to Fracture Mechanics **L-T-P-CH-CR: 3-0-0-3-3**

Fatigue: Mechanisms of fatigue crack initiation and propagation; Notch sensitivity; Factors influencing fatigue strength, Prevention of fatigue failure.
Introduction to fracture: Failure and fracture, Types of fracture, Modes of fracture failure.
Energy of Fracture: Energy balance during crack growth, Griffith's theory, Crack stability, Fracture criterion, Strain energy release rate.
Linear Elastic Fracture Mechanics: Analysis of crack tip stress, Irwin's fracture criterion,
Determination of stress intensity factor, Fracture toughness.
Elastic-Plastic Fracture Mechanics: Crack tip opening displacement, J-Integral and its applications;
Computational Fracture Mechanics: Finite element method, Virtual crack extension, Virtual crack closer integral;
Advanced Topics: Fracture in composite, Fracture in nanometer scale.
Case studies on fracture failure.

Textbooks

1. Kumar, P. Elements of Fracture Mechanics (Tata McGraw-Hill, New Delhi, 2009)
2. Anderson, T.L. Fracture Mechanics: Fundamentals and applications (3rd ed., CRC Press, 2005)

References

1. Sanford R.J. Principles of Fracture Mechanics (Prentice Hall, 2003)
2. Bolotin V.V. Mechanics of Fatigue (CRC Press, 1999)
3. Broek, D. Elementary Engineering Fracture Mechanics (Kluwer Academic Publishers, 1986)
4. Rolfe S.T. and Barsom J.M. Fracture and Fatigue Control in Structures: Applications of Fracture Mechanics (Butterworth-Heinemann, 2000)
5. Maiti S.K. Fracture Mechanics: Fundamental and Applications (Cambridge University Press, 2015)
6. Kundu T, Fundamental of Fracture Mechanics (CRC Press, Taylor & Francis, 2008)
7. Kuna M. Finite Elements in Fracture Mechanics (Springer, 2013)
8. Gdoutos E. E. Fracture of Nano and Engineering Materials and Structures (Springer, 2006)

ME521: Robotics **L-T-P-CH-CR: 3-1-0-4-4**

Introduction: A brief history; Types of robots; Basic principles in robotics; Notation.
Mathematical Representation of Robots: Position & orientation of a rigid body; Transformation between coordinate systems; Homogeneous transformation and its properties; Representation of joints; Representation of links using Denavit-Hartenberg parameters; Link transformation matrices.
Kinematics of Serial Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematics problem; Redundant manipulators.

Velocity Analysis and Statics of Manipulators: Linear and angular velocities of a rigid body; Linear and angular velocities of links in serial manipulators; Jacobian; Singularities of serial manipulators;
Statics of serial manipulators; Redundancy resolution.
Elements of Kinematics of Parallel Manipulators: Degrees of freedom; Direct kinematics problem;
Inverse kinematic problem; Mobility of parallel manipulators; Jacobian, Statics & Singularity.
Dynamics of Manipulators: Forward and inverse dynamics of manipulators; Newton-Euler and Lagrangian formulations.
Trajectory Planning and Generation: General considerations in path description and generation; Joint space schemes; Cartesian space schemes.
Position and Force Control of Manipulators: Feedback control of a single-link manipulator; PID control of a multi-link manipulator; Non-linear control of manipulators; Partitioning a task for force and position control; Hybrid position/force controller; Stability analysis.
Elements of a Robot: Actuators, Transmission & Sensors.

Textbooks

1. Ghosal A. Robotics - Fundamental concepts & Analysis (Oxford university press, 2006)
2. Craig J. J. Introduction to Robotics - Mechanics & Control (Addison - Wesley Publishing Company, New York, 1986)

References

1. Asada H. and Slotine J. E. Robot Analysis & Control (John Wiley & Sons, New York, 1986)
2. Nakamura Y. Advanced robotics - Redundancy & Optimization (Addison - Wesley Publishing Company, New York, 1991)
3. Merlet J.P. Parallel Robots (Kluwer Academic Publishers, Netherlands, 2000)

ME522: Quality Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Basic definition of quality, new and old culture, dimensions of quality, Deming's philosophy. Quality of leadership: Leadership concept and characteristics, vision and mission statement, strategic planning. Customer satisfaction: Introduction, customer supplier chain, feedback, translating needs into requirements, customer retention. Involvement of employee: Continuous process improvement: Introduction, Input/ out process model, Juran Triology, Plan-Do-Study-Act (PDSA) cycle, Problem solving method. Supplier Partnership: Introduction, Supplier selection, principle of customer/supplier relations, supplier selection, rating and certification, Relationship development. Performance evaluation: Basic concepts, Quality cost, Cost categories, Optimum cost, Quality cost analysis, Reporting,

Statistical process control (SPC): Histogram, Pareto Analysis, Process flow diagram, Cause and effect diagram, check sheet, statistical fundamental, X and R chart, Chart for attributes, scatter diagram. ISO9000& 14000: Introduction, ISO 9000 series standards, elements of ISO/QS 9000, steps to implement quality systems, ISO 14000 series standards, concepts and requirements of ISO 14001, EMS benefits. Benchmarking, Quality function deployment: Introduction, benefits of QFD, the voice of the customer, affinity diagram, Building of a house of quality, QFD process. Taguchi's quality engineering: Taguchi's loss function, step and quadratic function, signal- to- noise (S/N) ratio, Orthogonal Array. Reliability and its requirement, failure rate, reliability function derivation, Weibull distribution, Conditional probability distribution, system reliability, reliability of system with standby components, reliability improvement.

ME523: Non-Conventional Energy **L-T-P-CH-CR: 3-0-0-3-3**

Introduction: Importance of non-conventional energy, sources of non-conventional energy and their application. Advantages of non-conventional energy over fossil fuel.
Biomass energy: types of biomasses- plant waste and animal waste, conversion techniques of biomass into energy, biogas plant, modern techniques of biomass conversion, advantages and disadvantages of biomass energy, gobar gas.
Hydroelectric energy: mechanism of hydroelectric power generation, hydroelectric dam, sizes and capacities of hydroelectric plant, present and future scenario of hydroelectric energy and its positive and negative aspect in society.

Wind energy: types of wind turbine, wind mill, offshore and onshore wind power, capacity factor.
Solar energy: Application of solar energy as heating electricity generation and fuel production, solar panel, development of solar energy techniques, energy storage methods.
Tidal power: tide mills, generating method of tidal power, tidal barrage and dynamic tidal power, tidal power issues-ecological and corrosion.
Geothermal energy: geothermal gradient, hot springs, electricity generation, direct application of geothermal energy, environmental effects.
Fuel cell: types of fuel cell, Phosphoric acid fuel cell (PAFC), high temperature fuel cell-SOFC, MCFC, application-fuel cell electric vehicle (FCEV), Hydrogen energy.

Textbooks and references

1. Non-Conventional Energy Resources, B H Khan, McGraw Hill Education (India) Private Limited, New Delhi.
2. Non-Conventional Energy Resources, G S Sawhney, PHI Learning, Delhi.
3. Reviews of Renewable Energy Sources, M S Sodha, S S Mathur, and M A S Malik, Wiley Eastern. New Delhi.
4. Renewable energy technologies, R Ramesh, Narosa Publishing House, New Delhi
5. Renewable energy and environment, proceedings of the National Solar Energy Convention, 1989, N S Rathore, Himanshu Publications, New Delhi.
6. Solar Energy: Principles of Thermal Collection and Storage, K Sukhatme and S P Sukhatme, Tata McGraw Hill, New Delhi.
7. Wind Energy Technology, John F. Walker and Nicholas Jenkins, John Wiley and sons Canada, Limited.

ME525: Tribology **L-T-P-CH-CR: 3-0-0-3-3**

UNIT I Introduction: Definition of tribology with examples, Tribological systems – economic benefits and importance, History of tribology, Modern applications of tribology, Role of surface roughness and elastic deformation in tribology.
UNIT II Wear: Introduction, Wear mechanisms – abrasive, adhesive, cavitation, corrosive, erosive, fatigue and fretting wear, Quantitative laws of wear, Measurement of wear, Wear analysis, Wear resistance materials. Friction: Causes of friction, Theories of friction – adhesion theory, junction growth theory; Laws of rolling friction, Measurement of friction, Methods of reducing friction.
UNIT III Lubricants and Lubrication: Introduction, Boundary lubrication, Hydrostatic, Hydrodynamic and Elasto-hydrodynamic lubrication, Mixed lubrication. Lubricants – types and properties of lubricants, lubricant additives, and testing methods of lubricants. Contact systems: Principles and applications of Rolling contact bearings, Cams, Gears.
UNIT IV Bearings: Purpose, classification and properties of bearing, Failure modes of bearing, Bearing materials, Hydrostatic bearing lubrication – advantages & disadvantages; Hydrodynamic gas lubricated bearings.

Text books:
1. Halling J., “Principles of Tribology”, The Macmillan Press Ltd, London, 1975.
2. Srivastava S.K., “Tribology in Industry”, S. Chand and Company, 2004.
Reference books:
1. Hutchings IM, “Tribology, Friction and Wear of Engineering Material”, Edward Arnold, London, 1992
2. Wiliams J.A, “Engineering Tribology”, Oxford University Press, 2005.
3. Mazumdar B.C., “Introduction to Tribology of Bearings”, S. Chand and Company, 2010.

ME528: Energy Conservation and Waste Heat Recovery **L-T-P-CH-CR: 3-0-0-3-3**

Prerequsites: **ME308**

Energy resources and use. Potential for energy conservation. Optimal utilization of fossil fuels. Total energy approach. Coupled cycles and combined plants. Cogeneration systems. Exergy analysis. Utilization of industrial waste heat. Properties of exhaust gas. Gas-to-gas, gas-to-liquid heat recovery systems. Recuperators and regenerators. Shell and tube heat exchangers. Spiral tube and plate heat exchangers. Waste heat boilers: various types and design aspects. Heat pipes: theory and applications in waste heat recovery. Prime movers: sources and uses of waste heat. Fluidized bed heat recovery systems. Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems. Thermoelectric system to recover waste heat. Heat pump for energy recovery. Heat recovery from incineration plants.

Utilization of low grade reject heat from power plants. Need for energy storage: Thermal, electrical, magnetic and chemical storage systems. Thermo-economic optimization.

References

1. Harlock, J.H. *Combined Heat and Power* (Pergaman Press, 1997)
2. Kreith, F. and West, R.E. *Energy Efficiency, CRC handbook* (CRC Press,1999)
3. Kays and London, *Compact Heat Exchangers* (McGraw-Hill, New York, 3/e, 1958)

ME531: Project Management **L-T-P-CH-CR: 3-0-0-3-3**

Unit 1: Introduction and basic fundamental: Importance of Project management, Project selection, Project Definition/Project Charter (SOW), Project Goal, Types of project, Project Life-cycle model, Project stakeholders, Organizational influences, Project management processes and mapping, Project Process flow diagrams, Project idea generation and acceptance; Modelling the project system.

Project analysis and feasibility report.

Unit 2: Project Scope: scope definition, scope planning, Project Breakdown Structure (WBS), Scope verification, scope control.

Unit 3: Project Planning and Scheduling techniques, Resource Scheduling: Resource allocation method, splitting and multitasking, Multi-project resources scheduling, Critical chain scheduling- Concept, method, application and limitations. Project integration management, PMP, Direct and manage project execution, Performance measurement and control, Project monitoring and Control, earned value method and milestone monitoring. PERT/CPM.

Unit 4: Project Time management, activity definition, activity sequencing, resource estimating, duration estimating, schedule development and control, Project cost estimating, cost budgeting and cost control.

Unit 5: Human resource management, HR planning, acquire, develop and manage project team, performance reporting and manage stakeholders. Project risk management.

Overview of software project management. Software for project management.

Textbooks

1. Gray, C. F., Larson, E. W. and Desai G. V. Project Management -The Managerial Process. McGraw Hill Education Private Limited, New Delhi, 4th edition, 2010.
2. Maylor, H. Project Management. Pearson Education Limited. New Delhi, 3rd edition, 2003.

References

1. Chandra, P. Project Preparation, Appraisal and Implementation. Tata McGraw Hill Publishing Company, New Delhi, 7th edition, 2009.
2. Burke, Rory. Project management - Planning and Control Techniques. John Wiley & Sons, Inc., 5th edition, 2013.
3. Lientz, B. P. and Rea, K. P. Project Management – for 21st Century, Academic Press, 4th edition, 1995.
4. Heerkens, G. R. Project Management, McGraw-Hill, 2nd edition, 2013.

ME532: Power Plant Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Introduction: economics of power generation, load curves, load and load types, load factor, base and peak loads, reserved capacity, plant capacity, annual depreciation, energy cost calculations.

Steam cycle analysis: Rankine cycle, work and heat interactions, steam and heat rate, thermal efficiency, ideal reheat and regenerative rankine cycles, feedwater heaters, deaeration, cogeneration, topping and bottoming cycles.

Combined cycle power generation: working fluid, coupled cycles, series and parallel combination with heat loss, steam and other working fluids.

Steam Generators: Boilers, economisers, superheaters, reheaters, air preheaters, FBB, electrostatic precipitators, boiler efficiency, blowdown.

Steam turbines: high pressure and low pressure turbines, condensing and noncondensing turbines, nozzle flow, nozzle efficiency, choked flow, impulse and reaction turbines, compounding of steam turbines, diagram efficiency, governing of steam turbines.

Condensers, feedwater and circulating systems: Theory and analysis of condensers, feedwater heaters, cooling towers. .

Nuclear power plants: Half-life, nuclear fission, reflectors, nuclear reactors, PWR, BWR, heavy water reactors, liquid metal fast breeder reactors.

Hydroelectric power plants: Overview of pelton wheel, francis turbine, propeller and kaplan turbines, specific speed, cavitation, surge tanks, performance characteristics, turbine size, turbine selection.

Textbooks and references

1. Power Plant Engineering, P.K.Nag, Tata McGraw Hill Education Pvt.Ltd.,3e, New Delhi

2. Power Plant Technology, M.M.El-Wakil, McGraw Hill.

3. Power Plant Engineering, Arora & Domkundwar, Dhanpat Rai & Co., Delhi.

4. Power Plant Engineering, C.Elanchazhian, I.K. International, Delhi.

5. Power Plant Engineering, Nagpal, Khanna Publishers, Delhi

6. Boiler Operator's Handbook, Kenneth E. Heselton, Fairmont Press, Inc, 2e.

7. Thermodynamics: An Engineering Approach Hardcover – Feb 2014, M.Boles & Y. Cengel, McGraw Hill Education, 8e.

ME534: Mechantronics **L-T-P-CH-CR: 3-0-0-3-3**

Introduction: Definition of mechatronics. Mechatronics in manufacturing, products and design. Review of fundamentals of electronics.
Mechatronics elements: Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers.
Processors /controllers: Microprocessors, microcontrollers, PID controllers and PLCs.
Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.
Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits.
Pneumatic system: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems.
CNC technology and Robotics: CNC machines and part programming. Industrial Robotics.

Textbooks:

1. Boucher, T. O., Computer automation in manufacturing - an Introduction, Chapman and Hall, 1996.
2. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988

References:

1. Deb, S. R., Robotics technology and flexible automation, Tata McGraw-Hill, New Delhi, 1994.
2. Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman, Singapore, 1999.

ME537: Applied Computational Methods **L-T-P-CH-CR: 3-1-0-4-4**

Approximations and error analysis;

Roots of single-variable nonlinear equations - bracketing methods, bisection method, false position method, fixed point iteration, Netwon-Raphson method and secant method;

Roots of singe-variable polynomials - polynomial deflation, Bairstow's method and Muller method;

Solution of linear system of equations - Gauss elimination method, Gauss-Jordan method, matrix inversion, LU decomposition, Jacobi iteration and Gauss-Seidel iteration;

Solution of nonlinear system of equations - fixed point iteration, Newton's method, Jacobian matrix and Seidel iteration;

Curve fitting - least-square line fitting, exponential curve fitting, Lagrange polynomial and Newton's polynomial, interpolation by piecewise linear, quadratic and cubic splines;

Eigenvalues and eigenvectors of homogenous and symmetric matrices;

Numerical differentiation - finite difference methods;

Numerical integration - trapezoidal rule, Simpson's rules, Romberg integration and Gauss quadrature;

Solution of ordinary differential equations - Euler and Runge-Kutta methods for initial value problem, shooting and finite difference methods for boundary value problems, eigenvalue problems;

Solution of partial differential equations - elliptical and parabolic equations;

Assignment and mini-project.

Textbooks

1. Chapra, S.C. and Canade, R.P. *Numerical Methods for Engineers* (Tata McGraw-Hill, 2006)
2. Mathews, J.H. Numerical Methods for Mathematics, Science and Engineering (Prentice-Hall of India, 2000)

References

1. Gerald, C.F. and Wheatley, P.O. *Applied Numerical Analysis* (Addison-Wesley, 2003)
2. Tayler, A.B. Mathematical Models in Applied Mechanics (Clarendon Press, 2001)
3. Boresi, A.P., Chong, K.P. and Saigal, S. *Approximate Solution Methods in Engineering Mechanics* (John Wiley & Sons, 2002)
4. James, M.L., Smith, G.M. and Wolford, J.C. *Applied Numerical Methods for Digital Computation* (Harpercollins College Div, 1992)

ME538: Computer-Aided-Design in Engineering **L-T-P-CH-CR: 3-1-0-4-4**

Overview of computer aided engineering design;

Transformation - representation and transformation of points, homogeneous coordinates, rotation, reflection, translation, scaling and sharing of lines, combined transformation, solid body transformation;

Projections - orthographic, axonometric, oblique and perspective projections;

Plane curves - parametric and nonparametric curves like circle, ellipse, parabola and hyperbola; Conic sections;

Space curves - cubic splines, parabolic blending, Bézier curves and B-spline curves;

Surface Generation - surface of revolution, sweep surface, quadric surface, bilinear surface, ruled and developable surfaces, Coons linear surface, Coons bicubic surface, Bézier surface, B-spline surface and composite surface;

Solid body modeling - designing three-dimensional models like machine parts, hidden line and surface removal;

Application of commercial solid modelers; Assignment and mini-project.

Textbooks

1. Rogers, D.F. and Adams, J.A. *Mathematical Elements for Computer Graphics* (Tata McGraw-Hill, 2002)
2. Mortenson, M.E. *Mathematics for Computer Graphics Applications* (Industrial Press, 1999)

References

1. Plastock, R.A. and Kalley, G. *Computer Graphics* (McGraw-Hill, 1986)
2. Mortenson, M.E. *Geometric Modeling* (John Wiley & Sons, 1985)
3. Ryan, D.L. *Computer-Aided Graphics and Design* (Marcel Dekker, 1994)

ME539: Optimization Techniques in Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Introduction – definition and importance of optimization, basic terminologies, general problem formulation;

Single variable unconstrained optimization – first and second order optimality criteria, bracketing and refining optimum point, direct search methods, gradient-based search methods;

Multi-variable unconstrained optimization - first and second order optimality criteria, unidirectional search, direct search methods, gradient-based search methods;

Constrained linear programming problems – simplex method, duality in linear programming;

Constrained nonlinear programming problems - Kuhn-Tucker conditions, sensitivity analysis, penalty function methods, method of multipliers, direct search methods, sequentially linearized methods, feasible direction method, gradient-based search methods, quadratic programming;

Specialized algorithms for integer and geometric programming problems;

Application of different optimization methods to mechanical design problems;

Assignment and mini-project.

Textbooks

1. Deb, K. *Optimization for Engineering Design – Algorithms and Examples* (Prentice-Hall of India, 1995)
2. Arora, J.S. *Introduction to Optimum Design* (Academic Press, 2004)

References

1. Belegundu, A.D. and Chandrupatla, T.R. *Optimization Concepts and Applications in Engineering* (Pearson Education, 1999)
2. Rao, S.S. *Optimization: Theory and Applications* (Wiley Eastern, 1984)

ME540: Evolutionary Algorithms for Optimum Design **L-T-P-CH-CR: 3-0-0-3-3**

Introduction - brief review of classical optimization methods, definition and importance of nontraditional techniques;

Evolutionary algorithms (EAs) – solution representations for different types of variables, population initialization and evolution;

Genetic algorithm - selection, crossover and mutation operators; Differential evolution – mutation, crossover and selection operators; Particle swarm optimization – personal and global best particles, velocity and position of a particle;

Constraints handling and elite preservation in EAs; Influence of algorithmic parameter values in EAs and hybridized EAs;

Multi-objective optimization – concept of dominance, non-dominated sorting, diversity of solutions, Pareto front;

EAs to different types of problems, in particular to mechanical design problems including structural shape design;

Performance measurements of multi-objective optimizers - concept of dominance relation among Pareto fronts, performance metrics and their properties, statistical methods for comparing performances of multi-objective optimizers;

Assignment and mini-project.

Textbooks

1. Sivanandom, S.N. and Deepa, S.N. *Introduction to Genetic Algorithms* (Springer, 2010)
2. Price, K.V., Storn, R.M. and Lampinen, J.A. *Differential Evolution: A Practical Approach to Global Optimization* (Springer, 2005)
3. Olsson, A.E. *Particle Swarm Optimization: Theory, Techniques and Applications* (Nova Science Pub, 2011)
4. Deb, K. *Multi-Objective Optimization using Evolutionary Algorithms* (John Wiley & Sons, 2001)

References

1. Coello Coello, C.A., Lamont G.B. and van Veldhuizen, D.A. *Evolutionary Algorithms for Solving Multi-Objective Problems* (Springer, 2007)
2. Tan, K.C., Khor, E.F. and Lee, T.H. *Multiobjective Evolutionary Algorithms and Applications* (Springer, 2005)
3. Chakraborty, U.K. *Advances in Differential Evolution* (Springer, 2008)
4. Clerc, M. *Particle Swarm Optimization* (John Wiley & Sons, 2010)
5. Mann, P.S. *Introductory Statistics* (John Wiley & Sons, 2004)

ME542: Computational Fluid Dynamics **L-T-P-CH-CR: 3-1-0-4-4**

Basic equations of fluid dynamics - general form of a conservation law, equation of mass conservation, conservation law of momentum, conservation equation of energy;

Dynamic levels of approximation - Navier-Stokes (NS) equation, Reynolds-averaged NS equations, thin layer and parabolised NS approximations, boundary layer approximation, Euler equations for inviscid rotational and potential flows, small disturbance approximation of potential flow, linearized potential flow, nature of PDE and flow equations;

Basic discretization techniques - explicit and compact schemes for spatial discretization, central and upwind schemes; Integration of system of ODEs - explicit and implicit methods, multi-step methods, predictor-corrector schemes, ADI methods, Runge-Kutta schemes;

Analysis and application of numerical schemes – consistency, stability, convergence, von Neumann stability analysis, modified equation, application of finite difference method to wave, heat, Laplace and Burgers equations; Linear solver - error and convergence properties of $Ax=b$ as encountered in CFD, successive over-relaxation, ILU factorization;

Finite volume methods - finite volume discretization of time derivative, convective term and dissipative term;

Numerical solution of Euler equations - formulation of system of Euler equations, space-centered schemes, upwind schemes, shock-tube problem, numerical solution of incompressible NS equations - streamline-vorticity formulation, primitive variable formulation, staggered and collocated grids, pressure-correction algorithms, Lid-driven cavity flow;

Assignment and mini-project.

Textbooks

1. Anderson, J.D. *Computational Fluid Dynamics* (McGraw-Hill, 1995)
2. Ferziger, J.H. and Peric, M. *Computational Methods for Fluid Dynamics* (Springer, 2002)

References

1. Pletcher, R., Tannehill, J.C. and Anderson, D. *Computational Fluid Mechanics and Heat Transfer* (Taylor & Francis, 2011)
2. Versteeg, H.K. and Malalasekera, W. *An Introduction to Computational Fluid Dynamics: The Finite Volume Method* (Longman, 1995)
3. Patankar, S.V. *Numerical Heat Transfer and Fluid Flow* (Hemisphere, 1980)
4. Hirsch, C. *Numerical Computation of Internal and External Flows*, Vol. 1 and 2 (John Wiley & Sons, 1990)

ME543: Compressible Flow **L-T-P-CH-CR: 3-1-0-4-4**

Review of thermodynamics and fluid mechanics, integral forms of conservation equations, differential conservation equations, Crocco's theorem, speed of sound and Mach number;

Basic equations for one dimensional flows, isentropic relations, normal shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curves, Mach waves, oblique shock wave, attached and detached shock waves, shock polar, shock interaction and reflection;

Linearized subsonic flow, linearized supersonic flow, small perturbation theory, Prandtl-Meyer expansion waves, method of characteristics;

Quasi-one-dimensional flows – governing equations, area-velocity relations, isentropic flow through variable area ducts, convergent-divergent nozzles, over-expanded and under-expanded nozzles, diffusers;

Unsteady wave motion – moving normal shock waves, reflected shock waves, physical features of wave propagation, elements of acoustic theory, incident and reflected shock waves, shock tube relations, incident and reflected expansion waves, finite compression waves;

Hypersonic gas dynamics – general characteristics of hypersonic flow, hypersonic shock and expansion relations, similarity parameters, determination of surface pressure distribution in hypersonic flow field, hypersonic boundary layer;

Aero-test facilities – closed and open circuit wind tunnels, supersonic wind tunnels, shock tunnels, impulse facilities, hypersonic wind tunnels, shock tunnels; Assignment and mini-project.

Textbooks

1. Anderson, J.D. *Modern Compressible Flow with Historical Perspective* (McGraw-Hill, 1990)
2. Liepmann, H.W. and Roshko, A. *Elements of Gas Dynamics* (Dover, 2007)

References

1. Shapiro, A. *The Dynamics and Thermodynamics of Compressible Flow* (Ronald Press, 1950)
2. Anderson, J.D. *Hypersonic and High Temperature Gas Dynamics* (McGraw-Hill, 1990)
3. Barlow, J.B, Rae, W.H. and Pope, A. *Low Speed Wind Tunnel Testing* (John Wiley & Sons, 1999)
4. Pope, A. and Kennith, L.G. *High Speed Wind Tunnel Testing* (John Wiley & Sons, 1965)
5. Lukasiewicz, J. *Experimental Methods of Hypersonics* (Mercel Dekker, 1973)

ME544: Turbulent Shear Flow **L-T-P-CH-CR: 3-0-0-3-3**

Nature of turbulent flows, equations of fluid motion – continuity, momentum, conserved passive scalars;

Statistical description of turbulent flows – random nature of turbulence, characteristics of random variables, joint random variables, normal and joint-normal distribution;

Mean flow equations – Reynolds equations, Reynolds stresses, mean scalar equation, gradient-diffusion and turbulent-viscosity hypothesis;

Free shear flows – round jet, self-similarity, kinetic energy, other self-similar flows – plane jet, plane mixing layer, plane wake, axisymmetric wake;

Scales of turbulent motion – energy cascade, Kolmogorov hypothesis, energy spectrum, two-point correlation, Fourier modes, velocity spectra;

Wall flows – pipe flow, boundary layers, turbulent structures, direct numerical simulation;

Turbulent viscosity models – mixing-length model, turbulent-kinetic energy models, k-ε model;

Assignment and mini-project.

Textbooks

1. Townsend, A.A.R. *The Structure of Turbulent Shear Flow* (Cambridge University Press, 1980)
2. Pope, S.B. *Turbulent Flows* (Cambridge University Press, 2000)

References

1. Hinze, J.O. *Turbulence* (McGraw-Hill, 1975)
2. Schlichting, H. and Gersten, K. *Boundary-Layer Theory* (Springer, 2000)
3. Tennekes, H. and Lumley, J.L. *A First Course in Turbulence* (MIT Press, 1972)

ME545: Viscous Fluid Flow **L-T-P-CH-CR: 3-0-0-3-3**

Preliminary concepts, conservation of mass, momentum and energy;

Stokes law of viscosity and Navier-Stokes equations, governing equations of fluid motion in cylindrical-polar coordinates;

Exact solutions of the viscous flow equations - shear-driven (Couette) flows, pressure-driven (Poiseuille) flows, plane Couette-Poiseuille flows, plane stagnation-point flow, Stokes' first problem and similarity solution, Stokes' second problem;

Laminar boundary-layers - Prandtl's boundary-layer theory, boundary layers over flat plate and wedge, similarity solutions, integral analysis, one-parameter integral method, Karman-Pohlhausen approximation, correlation method of Thwaites, boundary-layer flow over a circular cylinder;

Laminar free-shear flows - jet, wake and mixing layer; Stability of laminar flows - Orr-Sommerfeld equation, Rayleigh's equation, indifference curves, stability analysis, laminar-turbulent transition;

Turbulent flow - fundamentals, Reynolds-averaged equations, boundary-layer equations, energy budget of turbulent fluctuations, structure of turbulent boundary-layer, law of the wall;

Assignment and mini-project.

Textbooks

1. White, F.M. *Viscous Fluid Flow* (Tata McGraw Hill, 2011)
2. Papanastasiou, T.C., Georgiou, G.C. and Alexandrou, A.N. *Viscous Fluid Flow* (CRC Press, 2000)

References

1. Ockendon, H. and Ockendon, J.R. *Viscous Flow* (Cambridge University Press,1995)
2. Zeytounian, R.K. *Theory and Applications of Viscous Fluid Fflow* (Springer, 2004)
3. Zeytounian, R.K. *Asymptotic Modeling of Atmospheric Flows* (Springer-Verlag, 1990)
4. Joseph, D.D. *Stability of Fluid Motions, Vol. 2* (Springer-Verlag, 1976)
5. Telionis, D.P. *Unsteady Viscous Flows* (Springer-Verlag, 1981)
6. Shankar, P.N. *Slow Viscous Flows* (World scientific, 2007)

ME546: Fluid Transportation Systems **L-T-P-CH-CR: 3-0-0-3-3**

Basic concepts in fluid mechanics, transport theorems, integral conservation principles, constitutive equations;

Differential conservation principles;

Dimensional analysis - theory and applications, dimensionless equations and numbers;

Transport phenomena at interfaces, introduction to boundary layer, momentum, heat and mass transport;

Fundamentals of two-phase flow, phase separation and settling behavior, slurry pipeline transportation;

Design methods, pneumatic conveying; Assignment and mini-project.

Textbooks

1. Hauke, G. *An Introduction to Fluid Mechanics and Transport Phenomena*, Series: Fluid Mechanics and Its Applications, Vol. 86 (Springer, 2008)

References

1. Deen, W.M. *Analysis of Transport Phenomena* (Oxford University Press, 1998)
2. Bird, R.B., Stewart, W.E. and Lightfoot, E.N. *Transport Phenomena* (Wiley, 2005)
3. Hershey, H.C. and Brodkey, R.S. *Transport Phenomena: A Unified Approach*, Vol. 1 & 2 (Brodkey Publishing, 2003)

ME547: Two Phase Flow **L-T-P-CH-CR: 3-0-0-3-3**

Introduction, hydrodynamics of gas-liquid flow - homogeneous, separated and drift-flux models;

Flow pattern maps, stratified, bubbly, slug and annular flows, bubble formation and dynamics;

Principles and applications of pneumatic transport;

Hydrodynamics of solid-liquid flow, design equations for hydrodynamic transportation, nucleate and film boiling, flow boiling, enhancement of boiling heat transfer coefficient, film and drop-wise condensation;

Experimental methods for boiling and two-phase flow; Assignment and mini-project.

Textbooks

1. Wallis, G.B. *One Dimensional Two-Phase Flows* (McGraw-Hill, 1969)
2. Brennen, C.E. *Fundamentals of Multiphase Flow* (Cambridge University Press, 2005)

References

1. Collier, J.B. and Thome, J.R. *Convective Boiling and Condensation* (Oxford Science Publications, 1994)
2. Ghiaasiaan, S.M. *Two-Phase Flow, Boiling and Condensation* (Cambrdige University Press, 2008)
3. Fan, L.S. *Principles of Gas Solid Flows* (Cambridge University Press, 1998)
4. Perker, S.M. and Helvaci, S.S. *Solid-Liquid Two-phase Flows* (Elsevier, 2008)

ME549: Conduction and Radiation Heat Transfer **L-T-P-CH-CR: 3-0-0-3-3**

Conduction: Derivation of energy equation for conduction in three dimensions – Initial and boundary conditions. Transient conduction- Concept of Biot number – Lumped capacitance formulation unsteady conduction from a semi-

infinite solid-solution by similarity transformation method, Solution of the general 1D unsteady problem by separation of variables, integral methods of analysis for transient conduction, lumped and partially lumped capacitance methods, boundary value problems and orthogonal functions, Fourier and Chebyshev series, solution using separation of variables, semi-infinite and infinite domains, Duhamel's theorem, Laplace transforms, Green's functions, Solution of steady state 2D problem – solution by variable separable method – concept of superposition and homogeneous boundary conditions.

Numerical solution of conduction problems: Basic ideas of finite difference method –forward, backward and central differences – Discretization for the unsteady heat equation. Solution of the 1D unsteady heat conduction equation

Radiation: Laws of thermal radiation. Radiation properties of surfaces, Concept of view factors, Radiation exchange in black and diffuse grey enclosures, Radiation effects in temperature measurement, Enclosure theory for surfaces with wall temperatures that are continuous functions of space. Spectrally diffuse enclosure surfaces. Specularly reflecting surfaces

Radiation in participating media: The equation of radiative heat transfer in participating media; radiative properties of molecular gases and particulate media; exact solutions of one-dimensional grey media; Approximate solution methods for one-dimensional media (optically thin and optically thick approximations). Concept of combined Conduction and Radiation with examples such as spacecraft radiator, solar radiation etc.

Textbooks

1. F. P. Incropera, D. P. DeWitt, Fundamental of Heat and Mass Transfer, 5th Edition, John Wiley & Sons, Inc., 2016
2. D. Poulikakos, Conduction Heat transfer, Prentice Hall, 1994
3. M.N. Ozisik, Heat Conduction, 2nd edition, John Wiley & Sons, 1993
4. R. Siegel and J.R. Howell, Thermal Radiation Heat Transfer, Taylor and Francis, 2002

References

1. G.E. Mayers, Analytical methods in Conduction Heat Transfer, McGraw Hill, 1971
2. V S Arpaci, Conduction Heat Transfer, Addison-Wesley, Reading, MA, 1966

ME550: Heat Transfer Equipment Thermal Design **L-T-P-CH-CR: 3-0-0-3-3**

Basic consideration of design, Classification of heat transfer equipments - Design of shell and tube heat exchanger – Finned surface heat exchanger, enhanced heat transfer techniques –Heat exchangers for special services - Plate and spiral plate heat exchanger – plate heat exchanger for Dairy industry – Heat pipes, Acceptable design of thermal system and economic consideration, Thermal design of heat exchange equipments such as Air pre-heaters, Economizer – Super heater and condensers, Selection of compact heat exchangers, Analysis and design of cooling towers, optimization of thermal design.

Text Books:

1. Bejan A., Tsatsaronis G., Moran, M. Thermal Design and Optimization, John Wiley & Son, Hoboken, 1996.
2. Kays, W.M. and London, A.L., Compact Heat Exchangers, McGraw-Hill, 1998

References:

3. Dunn, P. and Reay, D.A., Heat Pipes, Pergamon, 1994
4. Kakac, S. and Liu, H., Heat Exchangers, CRC Press, 2002.
5. Ganapathy, V., Applied Heat Transfer, Pennwell Books, 1982
6. Jaluria Y. Design and Optimization of Thermal Systems. 2nd Edition, Taylor & Francis Boca Raton (2008)

ME551: Renewable Fluid Power Technology **L-T-P-CH-CR: 3-0-0-3-3**

Statistical analysis of wind regimes, dynamics of data acquisition, time distribution, frequency distribution and statistical modeling. Wind energy conversion principles: Types and classification of wind energy conversion system, power, torque, speed characteristics, maximum power co-efficient. Wind velocity measuring instruments, factor affecting the wind energy output, Principles and performance analysis of wind pumps. Design concept and testing. Principles of wind electric generators, basic characteristics of electric generators. variable and constant speed machines. Mechanical considerations and speed coupling, stand along, grid interconnected wind turbine. Grid interconnection and instrumentation, system stability. Aerodynamic design principles; Aerodynamic theories, axial momentum, blade element and combined theory. Rotor characteristics, wind turbine design considerations, methodology, and theoretical simulation of turbines loss, modeling of wind turbines and testing methods. Aerodynamic, mechanical breaking mechanisms, control, dynamics of large wind turbine systems, instrumentation, control and economics.

Importance and place of hydropower in the total power scenario in India, comparison with thermal and nuclear power; economic and environmental considerations. Hydrology: Descriptive hydrology; Hydrograph; Mass curve; Storage; Dams. Water ways: Pressure conduits; Penstocks; Water hammer; Surge tanks. Selection of hydro–turbines and their accessories; Hydro-turbine design, installation, operation and maintenance. Tidal power plant, pumped hydro storage plant and multipurpose hydroelectric projects.

Text Books:

1. Johnson G. L. Wind Energy Systems (Electronic Edition), Prentice Hall, New Delhi, 2006.
2. Wagner H. and Mathur J. *Introduction to Hydro energy Systems : Basics, Technology and Operation*, Springer, 2011

References:

3. Hau E. *Wind Turbines: Fundamentals, Technologies, Application and Economics*, Springer, 2000.
4. Mathew S. *Wind Energy: Fundamentals, Resource Analysis and Economics*, Springer, 2006
5. Burton T. Sharpe D. Jenkins N. and Bossanyi E. *Wind Energy Handbook*, John Wiley, 2001
6. Nag P. K. *Power Plant Engineering*, Third Edition, Tata McGraw Hill, 2008.

ME552: Renewable Thermal Power Technology **L-T-P-CH-CR: 3-0-0-3-3**

Introduction to solar science, environment and different angles, Methodologies for Solar thermal conversion system, Solar thermal conversion coating technology, General description of solar thermal collectors – Flat plate collectors, improved design of solar thermal collector for enhanced heat transfer, Concentrating collectors, evacuated collector, Design of various types of Solar collectors, Performance of solar collectors ; ASHRE codes, Solar active and passive heating ; Solar cooling ; Conversion to mechanical energy ; Solar desalination, Solar drying, Industrial application, Solar energy storage ; Solar thermal power plant, Economics of solar processes; Modeling of solar thermal systems, Components and simulation ; Design and sizing of solar heating systems.

Biomass resource assessment, properties of biomass and its analysis, different energy conversion methods – combustion, gasification, pyrolysis, liquification, biomass pre-treatment and processing, Biomethenation technology, bio-diesel, improved wood stove, bio-hydrogen generation, electricity generation from biomass gasifier, cooling and cleaning methods of gas produced from gasifier, engine systems, petrol, diesel and duel fuel engine and purely producer gas fired technology.

Text Books:

1. Nayak, J. K. and Sukhatme, S. P. *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill, New Delhi, 2006.
2. Mukunda, H. S. *Understanding Clean Energy and Fuels from Biomass*, Wiley India, 2011

References:

3. Duffie J. A. and Beckman W. A. *Solar Engineering of Thermal Processes*, John Wiley, 2006
4. Goswami D. Y. Kreith F. and Kreider J. F. *Principles of Solar Eng*ineering, Taylor and Francis, 1999.
5. Garg H. P. and Prakash S. (1997); *Solar Energy: Fundamental and Application*, Tata McGraw Hill, 1997
6. Kishore V. V. N. *Renewable Energy Engineering and Technology*, TERI, 2009
7. Tiwari G. N. *Solar Energy: Fundamentals, Design, Modelling and Applications*, Narosa, 2002
8. Basu P. *Biomass Gasification and Pyrolysis: Practical Design and Theory*, Academic Press, New York, 2010
9. Loo S. V. and Koppejan J. *The Handbook of Biomass Combustion and Co-firing*, Earthscan, London, 2008

ME553: Refrigeration System and Component Design **L-T-P-CH-CR: 3-0-0-3-3**

Review of Basic Refrigeration Systems: Overview of Vapour-compression cycles, Multi-pressure systems, Vapour absorption cycles and Aircraft refrigeration cycles, Effects of operating parameters on the performance of the refrigeration cycles

Refrigerant compressors: Thermodynamic processes during compression, effect of clearance on work, capacity control of refrigerant compressors, construction features of reciprocating compressors, rotary compressors, screw

compressors, scroll compressors, centrifugal compressors, performance characteristics of centrifugal compressors, comparison of performance of reciprocating and centrifugal compressors, Lubrication oil and their compatibility issues.

Condensers and Evaporators: Heat rejection ratio, types of condensers, heat transfer analysis in condensers, Wilson's plot, Types of evaporators, heat transfer in evaporators, extended surface evaporators, augmentation of boiling hat transfer, pressure drop in evaporators. A simple comparison between water cooled and air-cooled based condenser Air-conditioning plants.

Expansion Devices: Types of expansion devices, automatic or constant pressure expansion valve, thermostatic-expansion valve, capillary tube and its sizing

Refrigerants: A survey of refrigerants, designation of refrigerants, selection of a refrigerant, thermodynamic, physical and chemical requirements, ozone depletion potential and global warming potential of CFC refrigerants, Substitutes for CFC refrigerants

Design of complete vapour compression system: The complete system, graphical method, analytical method, Newton-Raphson method, Optimal design of evaporator

Vapour absorption system: Common refrigerant-absorbent systems, modifications to simple vapour-absorption system, Thermodynamic analysis of LiBr – H_2O and H_2O-NH_3 systems.

Text Books:
1. C. P. Arora, "*Refrigeration and Air conditioning*", Third Edition, Tata McGraw Hill, 2009.
2. W. F. Stoecker, "*Refrigeration and Air conditioning*", McGraw-Hill, New York, 1958.

References:
3. K. E. Herold, R. Radermacher and S. A. Keli, *Absorption Chillers and Heat Pumps*, CRC Press, 1996.
4. T.H.Kuehn, J W Ramsey and J L Therelkeld, Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998

ME572: Advanced Engineering Materials **L-T-P-CH-CR: 3-0-0-3-3**

Advanced materials for engineering applications, engineering materials - metals, polymers, composites and ceramics;

Structure-property correlation - role of crystal structure, substructure and microstructure on material properties;

High performance structural metallic alloys and their applications, surface engineering of materials and their applications;

Piezoelectric materials, shape memory alloys, smart materials and composite materials and their applications;

Micro-electro-mechanical systems (MEMS) - characteristics of materials for MEMS applications and manufacturing techniques for MEMS components;

Materials for high temperature applications - various alloys and composites, diffusion bond coating;

Powder metallurgy; Selection of materials - materials aspects, cost and manufacturing considerations;

Applications of materials to automobile and transport vehicles, aerospace, power generation, armament, marine environment and ocean structures, materials for other specialized applications; Assignment and mini-project.

ME573: Quality Science and Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Part-I

Principle and practices of Quality engineering: Basic definition of quality, new and old culture, dimensions of quality, Deming's philosophy. Quality of leadership: Leadership concept and characteristics, quality council, core value and concept, vision and mission statement, strategic planning. Customer satisfaction: Introduction, customer supplier chain, feedback, translating needs into requirements, customer retention. Involvement of employee: Maslow's Hierarchy of Needs, Herzberg's Two Factor Theory, Employee wants, Empowerment, characteristics of a successful team,

recognition and reward, benefits from employee involvement. Continuous process improvement: Introduction, Input/ out process model, Juran Triology, Plan-Do-Study-Act (PDSA) cycle, Problem solving method. Supplier Partnership: Introduction, Supplier selection, principle of customer/supplier relations, supplier selection, rating and certification, Relationship development. Performance evaluation: Basic concepts, Quality cost, Cost categories, Optimum cost, Quality cost analysis, Reporting, Quality improvement strategy, Malcolm Baldrige National Quality Award.

Part-II

Statistical process control (SPC): Histogram, Pareto Analysis, Process flow diagram, Cause and effect diagram, check sheet, statistical fundamental, X and R chart, Chart for attributes, scatter diagram. ISO9000& 14000: Introduction, ISO 9000 series standards, elements of ISO/QS 9000, steps to implement quality systems, ISO 14000 series standards, concepts and requirement of ISO 14001, EMS benefits. Benchmarking: Definition, reasons for benchmarking, what to benchmark, planning, studying others, Pitfalls and Criticisms of benchmarking. Quality function deployment: Introduction, benefits of QFD, the voice of the customer, affinity diagram, Building of a house of quality, QFD process. Taguchi's quality engineering: Taguchi's loss function, step and quadratic function, signal- to- noise (S/N) ratio, Orthogonal Array. Liability of products: Introduction, product safety law, product liability law, proof and expert witness, financial loss, future of product liability. Failure mode and effect analysis (FMEA): Introduction, Reliability and its requirement, failure rate, intent of FMEA, FMEA documentation, Stages of FMEA, Design of FMEA document. Management tools: Introduction, forced field analysis, interrelationship digraph, Tree diagram, matrix

ME575: Advanced Materials for Design **L-T-P-CH-CR: 3-0-0-3-3**

Advanced materials for modern Engineering Design: Metals, Polymers, Composites and Ceramics; Proper material selection for design considerations

Structure-property correlation for design purposes: Role of crystal structure, substructure and microstructure on material properties and machine design

Metallic alloys for high performance structural design and their applications, Surface engineering of materials and their applications

Applications of Piezoelectric materials, Shape memory alloys, Smart materials and Composite materials in design of modern engineering components

Micro-electro-mechanical systems (MEMS) for design: Characteristics of materials for MEMS applications and MEMS components

Designing components for high temperature applications: Various alloys and composites, Diffusion bond coating

Application of Powder metallurgy technique in design: Selection of materials, Cost, Design and Manufacturing considerations involved

Advanced materials for design of Automobile and Transport vehicles, Aerospace, Power generation, Armament, Marine environment and Ocean structures, Materials for other specialized applications

Advanced material testing for machine design considerations

Assignment and mini-project.

ME579: Advanced Foundry Technology **L-T-P-CH-CR: 3-0-0-3-3**

Critical review of some foundry operations: Stages of casting; Pattern materials and allowances; Mould and Core practices: Materials and properties, Effect of process variables on property of core and mould making sand, Moulding factors in casting design, Metal-mould reaction; Mould and Core making machines: Mixer, Muller, Jolting, Squeezing, Jolt-squeezing, Slinging, Blowing and Shooting machines

Metal melting: Properties of liquid metals and their role in foundry technology: Thermal properties, Viscosity, Surface tension and Density; Melting furnaces for different types of metals and alloys: Electric arc furnace, Induction furnace, Rotary furnace, Cupola melting; Industrial melting practices and melt controls as adopted in case of Steel, Cast Iron and non-ferrous alloys; Binary and ternary equilibrium diagrams: Diffusional & diffusionless transformation, Concepts of structure-property-processing co-relation

Technology of Ferrous castings: Fe-C phase diagrams; Classification, properties and applications of steel and cast iron; Solidification behaviour and effect of alloy additions, De-oxidation and degassing of steel

Technology of Non-Ferrous castings: Non-ferrous alloys based on Al, Cu, Zn and Mg: Their properties and applications; Solidification and microstructure of important non ferrous alloys; Melt treatment: modification and grain refinement

Solidification of metals and alloys: Plane front solidification, Temperature gradient, Liquidus temperature profile and G/R ratio, Chworinov rule; Directional solidification: Controlling factors, Principles of Feeding, Gating and Risering, Design of gating system, Wlodawer system of determining feeder head requirements, Feeder head efficiency, Concept of feeding range; Casting grain structure and control: Ingot structure, Dendritic and cellular dendritic growth, Multiphase microstructures, Structure of casting as influenced by alloy constituents

Various casting processes: Special casting processes: Investment casting, Die casting, Centrifugal casting, Continuous casting, Full mould casting, Pressure casting, Vacuum shield casting, Shell mould casting and Composite moulds, Squeeze casting and semisolid metal forming

Casting design and simulation

Cleaning, Fettling, Salvaging and Heat treatments of castings

Casting defect analysis and remedies: Gas defects and their control: Simple and complex gases in metals; Inclusions and sand defects: Methods to prevent impurities from entering into castings; Shaping faults arising in pouring; Shrinkage defects during solidification in liquid phase, Contraction defects, Dimensional errors; Compositional errors and segregation: Micro & Macro segregation; Micro & Macro porosity and residual stresses in casting

Inspection and testing of casting defects

ME580: Advanced Metal Joining Technology	**L-T-P-CH-CR: 3-0-0-3-3**

Introduction: Theory and classification of welding and other joining processes

Welding Technology: Classifications; Review of major welding processes; Principles of Pressure and non-pressure welding, Fusion and non-fusion welding

Arc welding: Principle and striking of welding arc; Arc zones; Arc efficiency; Arc blow; Arc maintenance and stability

Manual metal arc welding: Equipment; Electrodes for structural steels; Coating constituents and their functions, Types of coatings; Current and voltage selection for electrodes, Power sources, Influence of power sources on welding, Conventional transformers, Rectifiers; Metal transfer and Heat transfer; Wire arc additive manufacturing (WAAM)

Submerged arc welding (SAW): Process details; Consumables for welding mild steel; Variations in the process; Advantages and Applications

Gas metal arc welding (GMAW) or MIG/MAG welding: Process details; Electrode wires, sizes and current ranges; Shielding gases; Advantages and Applications

Gas tungsten arc welding (GTAW) or TIG welding: Process details; Power source, Electrode sizes and materials, Current carrying capacity of electrodes; Shielding gases; Advantages and Applications

Electro-slag welding (EWS): Principle, advantages and applications

Plasma arc welding (PAW): Principle, advantages and applications; Modes of operation

Gas welding: Oxy-acetylene welding (OAW): Principle, advantages and applications; Types of flames

Resistance welding: Principles; Process details and working principle of spot, seam, flash, butt, projection and percussion welding; Electrode materials and shapes, Electrode cooling, Selection of currents and voltages; Advantages and applications

Thermit welding: Principle, advantages and applications

Modern welding processes: Electron beam welding (EBW); Laser beam welding (LBW); Diffusion welding; Explosion welding; Ultrasonic welding; Friction stir welding: Friction Stir Processing

Welding metallurgy of carbon and alloy steels, cast irons, stainless steels, Al and Cu based alloys: Microstructural evolution; Heat flow in welding: Heat affected zones

Weldability: Weldability of specific materials; Weldability tests

Design of welded joints: Welding positions; Weld design based on static, fatigue loading and fracture toughness

Weld Defects: Causes and corrective actions; Welding stresses and distortion; Imperfect shape or unacceptable contour; Cracks in welds; Incomplete fusion or penetration; Excessive spatter; Weld inspection: Detection techniques for weld defects; Non-destructive testing methods; Repair and maintenance of welding

Brazing and Soldering: Difference between Brazing, Braze welding and Soldering; Classification and methods of brazing and soldering; Filler metals; Consumables; Fluxes used, their purposes and flux residue treatment; Design and process capabilities

ME581: Advanced Metal Forming Technology **L-T-P-CH-CR: 3-0-0-3-3**

Mechanical working fundamentals: Hot, warm and cold working; Role of temperature, strain rate, friction and lubrication in metal working; Effect of working on structure and properties of metals and alloys: Microstructural evolution and control; Recovery, Recrystallisation and Grain growth; Concept of workability and its evaluation: Processing maps

Elements of theory of plasticity: Elementary theories and calculation of working load and power; Formulation of metal forming problems and different methods of solution; Applications of upper bound method for solving problems, Slip line theory and its applications

Forging Technology: Open and closed die forging: Manufacturing of typical components; Factors affecting metal flow in the die: Forgeability, Die design; Friction and Lubrication; Load and energy characteristics; Classification and Characterization of forging equipments: Classification, designation, metallurgical characteristics and applications of ferrous and nonferrous alloys; Forging defects and remedial measures: Recent Trends in Forging Technology: Net-shape technology; Powder forging; Precision forging; Flash less forging etc.

Rolling Technology: Classification of rolling mills; Theories of hot and cold rolling;Principles of modeling rolling processes: Pass design; Calculation of Geometrical relationships, Forces, Rolling load, Torque, and Power equations; Friction, Lubrication and Thermal aspects; Rolling Mills; Automatic control of mills;

Types of rolled products; Defects in rolled products; Cooling and de-scaling of products

Other mechanical working processes: Principles, equipment and manufacturing methods of Extrusion, Wire drawing and Tube making; Advances in sheet metal forming; Hydro-forming of sheets and tubes; Special working processes: Super plastic forming, High energy forming and Controlled rolling

ME582:Heat Treatment Technology **L-T-P-CH-CR: 3-0-0-3-3**

Significance of heat treatment in material processing for manufacturing industries: Concepts of processing-structure-property co-relation

Phase diagrams:

Binary and ternary equilibrium diagrams; Phase rule and Lever rule; Nucleation and growth of phases; Determination of grain size; Fe-C phase diagrams; Decomposition of austenite: Diffusion controlled and diffusionless transformations; Pearlitic and Bainitic and Martensitic transformations; TTT and CCT curves

Heat treatment processes:

Recrystallization annealing: Effect of working on structure and properties of metals and alloys; Microstructural evolution and control; Recovery, Recrystallization and Grain growth; Recrystallization temperature, Critical deformation; Annealing and its classifications: Full annealing, Isothermal annealing, Diffusion annealing, Partial annealing, Subcritical annealing; Normalizing, Hardening, Tempering, Thermo-mechanical treatment; Surface Hardening: Carburizing, Nitriding, Electron Beam Hardening, Laser Hardening Heat Treatment of tool and alloy steels, cast irons; Heat treatment of weldments

Heat treatment of non-ferrous metals and alloys:

Cast and heat-treatable alloys; Theory of age-hardening and precipitation; Aging time and precipitation temperature on mechanical properties of alloys

Heat Treatment defects and their remedial measures

Heat treating furnace atmosphere: Automation and computerization of heat treating process & equipment

ME601: Automobile Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Historical background, Introduction to different power plant for automotive vehicles. Layout of different kind of vehicle, resistance to vehicle motion and need of gear box, various types of gear box including automatic transmission systems, clutches including fluid coupling, torque converter, rear axle and final drive differential, front axle construction with constant velocity joint, steering system, suspension and chassis, brake including regenerative braking, recent development including electric vehicle, automobile electronics control system for energy optimization and electrical appliances. Automotive aerodynamics, design and pollution control.

Textbooks

1. Crouse, W.A. and Anglin, D.L. *Automotive Mechanics* (McGraw-Hill, New York, 2007**)**
2. Jain, *K.K and* Asthana, *R.B. Automobile Engineering* (Tata McGraw Hill, New Delhi, 2004)

References

1. Heitner, J. *Automotive Mechanics* (East-West Press, London, 1999)
2. Heisler, H. *Advanced Vehicle Technology* (Butterworth-Heinemann, Netherlands, 2002)
3. Limpert, R. *Brake Design and Safety* (SAE International, Pennsylvania, 1999)
4. Reimpell, J., Stoll, H., and Betzler, J.W. *The Automotive Chassis* (SAE International, Pennsylvania, 2010)
5. Ehsani, M., Gao Y and Emadi, A. *Modern Electric, Hybrid Electric and Fuel Cell Vehicles* (CRC, London, 2010).

ME603: Thermal power generation systems **L-T-P-CH-CR: 3-0-0-3-3**

Fundamentals of Thermodynamics: Introduction, Thermodynamic Properties and Basic Concepts, Laws of Thermodynamics, Exergy, Energy and Exergy balance, Efficiency Definitions.

Vapor power generation: The Rankine cycle, Carnotization of the Rankine cycle, Equivalent Carnot model and its analysis, parametric study of the Rankine cycle to investigate effect of turbine inlet temperature (TIT) boiler and condenser pressure on efficiency and power through thermodynamic modelling, optimization of the boiler pressure and selection of optimum boiler pressure**.**

Reheat cycle, effect of reheat pressure on power and efficiency, determination of optimal reheat pressure for maximum efficiency and power output, regenerative cycle with open and closed water heater, carnotization of the regenerative cycle, optimum degree of regeneration, analysis of cogeneration and tri-generation plants, working fluids for Rankine cycles and their selection, Organic Rankine cycle, Kalina cycle

Nuclear power generation: Nuclear fuels, Fission, Nuclear fission Reactions, Nuclear reactors: boiling water reactor, pressurized water reactor, High temperature gas cooled reactors, heat transfer and fluid flow analysis in nuclear reactor, Nuclear-Based Cogeneration Systems, Super critical vapor power cycle with single and double reheat.

Combined cycle power generation: Coupled cycles, Combined cycle (CC) plants, Gas turbine-steam turbine plant, supplementary firing, heat recovery steam generator, single pressure, dual pressure and triple pressure steam cycles

Advanced power generation systems: Supercritical Pulverized Coal Combustion, integrated gasification combined cycle (IGCC), steam injected gas turbine (STIG), Fluidized Bed Combustion (FBC) with sorbent injection, Pressurized Fluidized Bed Combustion (PFBC), Combined heat and power (CHP), Integrated Gasification Humid Air Turbine, Indirectly fired power systems (IFPS)

Textbooks

1. P.K.Nag, Power Plant Engineering, 2nd edition, Tata McGraw-Hill Education, 2002
2. C. Zamfirescu, I. Dincer. Advanced Power Generation Systems, Elsevier Science 2014, Netherland

References

1. R. Kehlhofer, B. Rukes, F. Hannemann, F. Stirnimann, Combined-Cycle Gas & Steam Turbine Power Plants, 3rd Edition, PennWell corporation 2009 USA

ME605: Hybrid Electric Vehicles **L-T-P-CH-CR: 3-0-0-3-3**

History of Electric Vehicles [1]- History of Hybrid Electric Vehicles, History of Fuel Cell Vehicles;

Vehicle Fundamentals [1]-General Description of Vehicle Movement, Resistance, Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation, Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed, Vehicle Power Plant and Transmission Characteristics, Power Plant Characteristics,

Transmission Characteristics, Gear Transmission, Hydrodynamic Transmission, Continuously Variable Transmission, Vehicle Performance ,Maximum Speed of a Vehicle, Gradeability, Acceleration Performance, Operating Fuel Economy, Internal Combustion Engines, Fuel Economy Characteristics of Internal Combustion Engines, of Vehicle Fuel Economy, Techniques to Improve Vehicle Fuel Economy, Braking Performance, Braking Force, Braking Distribution on Front and Rear Axles;

Electric Vehicles [2]-Configurations of Electric Vehicles, Performance of Electric Vehicles, Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Effort in Normal Driving, Energy Consumption;

Hybrid Electric Vehicles [3, 5]-Concept of Hybrid Electric Drive Trains, of Hybrid Electric Drive Trains Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Se -Coupling Parallel Hybrid Electric Drive Trains, Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains, Mild Hybrid Electric Drive Train Design;

Electric Propulsion Systems [2,4]-DC Motor Drives, Principle of Operation and Performance ,Combined Armature Voltage and Field Control, Chopper Control of DC Motors, Multiquadrant Control of Chopper-Fed DC Motor Drives, Two-Quadrant Control of Forward Motoring and Regenerative Braking, Induction Motor Drives, Basic Operation Principles of Induction Motors, Steady-State Performance ,Volt/Hertz Control, Power Electronic Control, Field Orientation Control, Voltage Source Inverter for FOC ,Voltage Control in Voltage Source Inverter, Current Control in Voltage Source Inverter, Magnetic Brush-Less DC Motor Drives, Basic Principles of BLDC Motor Drives, Control of BLDC Motor Drives, Extension of Speed Technology, Switched Reluctance Motor and its drives;

Energy Storages [5]-Electrochemical Batteries, Fuel Cells, Reactions, Thermodynamic Voltage Specific Energy Specific Power, Energy Efficiency, Battery Technologies, Lead-Acid Batteries, Nickel-based Batteries, Nickel/Iron System, Nickel/Cadmium System, Nickel–Metal Hydride (Ni–MH) Battery, Lithium-Based Batteries, –Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors, Features of Ultracapacitors, Basic Principles of Ultracapacitors, Performance of Ultracapacitors, Ultracapacitor Technologies, Ultrahigh-Speed Flywheels, Operation Principles of Flywheels, Power Capacity of Flywheel Systems, Flywheel Technologies, Hybridization of Energy Storages;

Fundamentals of Regenerative Braking [1]-Energy Consumption in Braking, Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Brake — Optimal Feel, Series Brake — Optimal Energy Recovery, Parallel Brake, Antilock Brake System (ABS)

Textbooks

1. Mehrdad Ehsani, Yimin Gao, Sebastien E Gay, Ali Emadi, Modern Electric , *Hybrid Electric and Fuel Cell Vehicles* (CRC Press, London, 2005)
2. Allen W.M. *Automotive Science and Mathematics* (Butterworth Heinemann, Netherlands, 2008)

References

1. Ali Emadi, *Handbook of Automotive Power Electronics and Motor Drives* (Taylor and Francis, London, 2005)
2. Allen W M Bonnick, *Automotive Computer Controlled Systems, Diagnostic Tools and Techniques* (Butterworth-Heinemann, Netherlands, 2001)
3. James Larminie, John Lowry, *Electric Vehicle Technology Explained* (John Wiley and Sons, Ltd., New Jersey, 2006)

ME606: Stability Problem in Applied Mechanics **L-T-P-CH-CR: 3-1-0-4-4**

Basic Dynamic Considerations:

Introduction; One-Dimensional Flows: Flows on the Line; Parameter Dependent Flows and Bifurcations; Flows on the Circle; Two Dimensional Dynamic Systems: Phase-plane Description; Linearized Stability Analysis; Limit cycle and its Stability; Parametric Instability: Floquet Theory.

Stability of Static Equilibrium:

Introduction; Euler's Method: Buckling of Columns; Energy Method: Approximate Solution; Non-adjacent Equilibrium Configuration: Snap Buckling; Asymmetric Deformation, Imperfection Sensitivity; Buckling due to Follower Load: Insufficiency of Static Analysis; Euler Buckling Load Revisited: Dynamic Analysis; Second Revisit of Buckling of Column (Euler Load); Other Examples of Instability.

Stability Problems in Dynamics:

Introduction; Different Notions of Stability; Stability of Equilibrium Configuration; Stability of a Rotating Rigid Body; Parametric Instability of a Linear Continuous System; Periodic Solution of Non-Linear Oscillators and its Stability.

Emergence of Length Scale and Pattern Formation:

Introduction; Stripes of Zebra Skin; Turning Pattern; Rayleigh-Taylor Instability; Staffman-Taylor Instability; Rayleigh-Plateau Instability; Rayleigh Benard Convection; On the Nature of Bifurcation; Faraday Instability; Rotating Couette Flow; Hydraulic Jump.

Textbooks:

1. Mallik, A. K. and Bhattacharjee, J. K. Stability Problems in Applied Mechanics, Narosa Publication (2005)

References:

1. Dym, C.L., Stability Theory & its application to Structural Mechanics, Noordhoff International Publications, Holland (1974)
2. Baznat, Z.P. and Cedolin, L., Stability of Structures, Oxford University Press, NY (1991)
3. Timoshenko, S.P. and Gere, J.M., Theory of Elastic Stability, Mc-Graw Hill, New York (1961)
4. Strogatz, S. H., Nonlinear Dynamics & Chaos, Addison-Wesley Pub. Co. Reading (1994)
5. Jordan D.W.and Smith, P., Nonlinear Ordinary Differential Equations, Clarendon Press, Oxford (1999)

ME607: Soft Computing Technique in Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Introduction to soft computing, hard computing, Need for soft computing;

Neurons and neural networks; Basic models of artificial neural networks – single-layer perceptron, multilayer perceptron; Radial basis function networks; SOM; Recurrent neural networks; Training of neural network; Applications of neural networks in mechanical engineering;

Introduction to fuzzy sets, Fuzzy reasoning and clustering;

Optimization tools: Traditional and non-traditional, genetic algorithms, simulated annealing etc.;

Combined techniques: Genetic Algorithms–Fuzzy Logic, Genetic Algorithms–Neural Networks,

Neural Networks–Fuzzy Logic.

Support Vector Machine (SVM) - introduction, principle and application.

Textbooks:

1. Pratihar D. K. Soft Computing (Narosa Publishing House, 2015)
2. Haykin S. Neural Networks: A Comprehensive Foundation (Pearson Education, 2nd ed., 2009)
3. Chen G. and Pham T.T. Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems (CRC Press, 2001)

References:

1. Dixit, P. M. and Dixit, U. S., Modeling of metal forming and machining processes: by finite element and soft computing methods, (Springer, 1st ed., 2008)
2. Deb K. Optimization for Engineering Design: Algorithms and Examples (Prentice Hall, 2006)
3. Aliev R.A. and Aliev R.R. Soft Computing and its Applications (World Scientific Publishing, 2001)

ME608: Mechatronics and Industrial Automation **L-T-P-CH-CR: 3-0-0-3-3**

Introduction to Mechatronics: Introduction, Elements of Mechatronics system, Applications.

Sensors and Actuators: Sensing principle, Electrical actuators, Hydraulic and Pneumatic actuators. Signal Processing: Signal conditioning devices, Protection, Conversion and pulse width modulation, Data conversion devices.

Microprocessors: Introduction to microprocessors, Introduction to microprocessor programming, Internal architecture of 8085 microprocessor.

Principles of Automation Technology: Automation system components, Discrete manufacturing automation, Continuous process automation.

Programmable Logic Controllers (PLC): Industrial Control, Structure of PLC, Programming languages for PLC, Boolean logic for process control, Timers, Counters and other functions.

Feedback Control: Continuous and Time- Discrete control, On/Off control, PID control, Distributed Control System (DCS)

Man machine communication: Supervisory control and data acquisition (SCADA)

Assignment and mini-project.

Textbooks

1. Bolton W. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (Pearson education, 2007)
2. Lamb F. Industrial Automation: Hands-On (McGraw-Hill Education, 2013)

References

1. Appukuttan K.K. Introduction to mechatronics (Oxford University Press, 2007)
2. Stenerson J. Industrial automation and process control (Prentice Hall, 2003)

ME609: Design of Internal Combustion Engine **L-T-P-CH-CR: 3-0-0-3-3**

Prerequisite for engineering design and design conditions of internal combustion engine components, Design of parts working under alternating loads, piston, piston ring and pin, Design of connecting rod small end, big end, shank and bolts, pressure on crank pin and journals, Design of crank web, inline and V engine crankshafts, Design of cylinder block, upper crankcase, liner, cylinder head and studs, Design of cam profile, harmonics of cam, valve gear, valve spring and camshaft, electronic control system for IC engine.

Textbooks

1. Hoag, K. and Dondlinger, K. Vehicular Engine Design (Springer, New York, 2016)
2. Smith, J. H. An Introduction to Modern Vehicle Design (Butterworth-Heinemann, Oxford, 2002)

References

1. Kolchin, A. and Demidov, V. Design of Automotive Engine (Mir Publisher, Moscow, 1984)
2. Fenton, J. Hand Book of Vehicle Design Analysis (Mechanical Engineering Publication Limited, London, 2013).

ME610: Kinematics and Dynamics of Internal Combustion Engine **L-T-P-CH-CR: 3-0-0-3-3**

Fundamentals of kinematics and dynamics, Different components of internal combustion engine, Types of IC Engine (Petrol, Diesel, 4 stroke , 2 strok4), Speed characteristics, Kinematics of crank mechanism comprising of piston stroke, speed and acceleration, Dynamics of crank mechanism comprising of gas pressure forces, masses of crank mechanism, inertial forces, total forces acting in crank mechanism, forces acting on crank pins, forces acting on main journals, crankshaft journals and pin wear, Balancing of diverse types of engines, uniformity of engine torque.

Textbooks

1. Hoag, K. and Dondlinger, K. Vehicular Engine Design (Springer, New York, 2016)
2. Smith, J. H. An Introduction to Modern Vehicle Design (Butterworth-Heinemann, Oxford, 2002)

References

1. Kolchin, A. and Demidov, V. Design of Automotive Engine (Mir Publisher, Moscow, 1984)
2. Fenton, J. Hand Book of Vehicle Design Analysis (Mechanical Engineering Publication Limited, London, 2013).

ME622: Communication Skills for Scientists and Engineers **L-T-P-CH-CR: 2-1-0-3-3**

Structure of a scientific paper: Know your readers before you write. What should be in abstract, introduction, main body, conclusions, and references?
Copying safely and avoiding plagiarism: How to cite an existing work including author's own work? How to copy from an existing work? Implications of plagiarism.
Communicating with a journal editor and conference chairs: Do's and Do-not's.
Presentation skill development: How to present work of two years in 20 minutes? What to say and how to say them?
Document writing in LaTeX: Introduction - what is LaTeX, how to write and compile a LaTeX document? Macros - commands, environments and packages; Insertion of keyboard characters; Fonts – text-mode and math-mode fonts, colored fonts; Texts formatting – sectional unit, labeling and referring, new line, paragraph, alignment, mini page, multiple columns, footnote, marginal note, blank space, miscellaneous; Page layout and style – default and formatted layout, page numbering, header and footer; Listing texts – numbered and unnumbered listing, listing with user-defined labels, tabbing; Symbols and mathematical expressions – text and math-mode symbols, mathematical expression in text-mode, simple equation, array of equations, complex equations; Figures – inserting figures from external file, side-by-side figures, figure wrapped by texts, drawing figures using LaTeX commands, plotting data file, bar chart; Tables – simple table, merging rows and columns, sideways (rotated) texts, side-by-side tables, table wrapped by texts, sideways

table, long table; Bibliographic references – different styles of bibliographic references; Documents – letter, research article, report, book; Slide preparation for presentation.

References

1. Mittelbach, F., Goossens, M., Braams, J., Carlisle, D. and Rowley, C. *The LaTeX Companion* (Addison-Wesley, 2004)

2. Lamport, L. and Bibby, D. *LaTeX : A Documentation Preparation System User's Guide and Reference Manual* (Addison-Wesley, 1994)