MANIPAL UNIVERSITY JAIPUR
B.TECH MECHANICAL ENGINEERING

BB0025 VALUE, ETHICS & GOVERNANCE [2 0 0 2]

Relevance of Value Education in day-to-day life. Mantra for success - Value, Moral and Ethics. Determinants of human nature (Three Gunas) and its impact on human life.Relevance of Personality, Attitude, Behaviour, Ego, Character, introspection, Motivation, Leadership and 4 Qs with relevant Case Studies*. Governance: Understanding of Public and Private sector Governance systems; Courts & CAG. Public Sector Governance: Need, relevance, stakeholders. Private Sector Governance: Proprietary, Partnership, Company (Pvt Ltd & Ltd), Company' Act 2013, Board of Directors; its Roles and Responsivities. Regulatory bodies; its role in ethical governance. Projects on PPP mode-relevance & prospects. CSR: Relationship with Society, Philanthropy and Business strategy, CSR Policy, Triple Bottom Line. Suggestive Case Studies:Uphar Theatre Tragedy- Engineering Ethics, Bhopal Gas Tragedy-Operational Engineering Ethics, Satyam Case- Financial Reporting Ethics, Enron Case- Business Ethics, Navin Modi Case- Financial Fraudulence.

References:

1. Professional Module of ICSI.
2. B.N. Ghosh, Business Ethics & Corporate Governance, McGraw Hill.
3. S.K. Mandal, Ethics in Business & Corporate Governance, McGraw Hill .
4. C.K. Ray, Corporate Governance, Value & Ethics, Vaya Education of India
5. Abha Chatterjee, Professional Ethics, Oxford Publications.

MA2102: ENGINEERING MATHEMATICS – III [2 1 0 3]

Gradient, divergence and curl, Line, surface and volume integrals. Green's, divergence and Stoke's theorems. Fourier series of periodic functions. Half range expansions. Harmonic analysis. Fourier integrals. Sine and cosine integrals, Fourier transform, Sine and cosine transforms. Partial differential Equation-Basic concepts, solutions of equations involving derivatives with respect to one variable only. Solutions by indicated transformations and separation of variables. One dimensional wave equation, one dimensional heat equation and their solutions. Numerical solutions of boundary valued problems, Laplace and Poisson equations and heat and wave equations by explicit methods.

References:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 7(e), John Wiley & Sons, Inc., 2015.
2. S.S. Sastry, *Introductory methods for Numerical Analysis*, (5e), PHI Learning Private Limited, 2012.
3. B.S. Grewal, *Higher Engineering Mathematics*, 43(e), Khanna Publishers, 2014.
4. R. Spiegel Murray, *Vector Analysis*, Schaum Publishing Co., 1959.

ME2101: MATERIALS SCIENCE AND ENGINEERING [3 0 0 3]

Introduction to Materials Science and Engineering: Materials classification. Crystallography SC, FCC, BCC, HCP structures, APF; Miller indices: Crystal structure Determination-X-ray diffraction techniques, Microscopic examination; Imperfections in Crystals: Point defects, line defects, surface defects. Plastic Deformation of Metals and Alloys, Mechanisms of plastic deformation, role of Dislocation; slip and twinning, grain growth, Solidification of Metals and Alloys: Solid solution, Hume Rothery's rules, Phase diagrams-Phase and Lever Rules relationship of micro Structure and properties, Iron- Carbon equilibrium diagram, Development of microstructure in Iron Carbon alloys, Phase transformation. Mechanical Properties of Metals; Fatigue and Failure of materials: S-N Curve, Fatigue failure. Polymers and applications: Types of polymers, structure and applications; Hydrocarbon and polymer molecules, Molecular weight, shape, structure and configurations, Thermosetting and thermoplastic polymers; Characteristics and Applications of Polymers; Mechanical behavior of polymers, mechanisms of deformation; Crystallization, Melting, and

Glass transition phenomena. Application and Properties of Ceramics: Types and applications of ceramics; Ceramic manufacturing; Mechanical and other properties. Fabrication of Plastics, Fibres and Films; Composites Materials: FRP, MMC, PMC and other types and applications; Fibre, Particle reinforced composites, Structural composites; Biocomposites, Nanocomposites, Composite micromechanics. Advanced Materials: Smart materials, Biomaterials, Nanomaterials.

References:

1. W.D. Callister, *Material Science and Engineering*, (2e), Wiley India Pvt. Ltd., 2014.
2. V. Raghavan, *Material Science and Engineering*, (6e), Prentice Hall of India, 2015
3. G.K. Narula and K.S Narula, V.K. Gupta, *Material Science*, (1e), Tata McGraw Hill, 2004.

ME2102: KINEMATICS OF MACHINES [2 1 0 3]

Introduction to mechanisms: kinematic pairs, kinematic diagrams, classification of kinematic chains, kinematic inversions and equivalent linkages. Kinematic analysis of planar mechanisms: mobility analysis and range of movement, Grashof's criteria and inversions, displacement analysis, instantaneous centers, Aronhold-Kennedy theorem, velocity and acceleration analysis. Cams: synthesis of translating flat-face, translating roller follower. Gears: fundamental law of gearing, characteristics of involute action, minimum number of teeth, analysis of gear trains. Introduction to clutch: Uniform pressure and wear theory.

References:

1. A.K. Mallik, A. Ghosh, *Theory of Mechanism and Machines*, (3e), Affiliated East-West Press (P) Ltd., 2015.
2. S.S. Rattan, *Theory of Machines*, (4e), Tata McGraw Hill, 2017.
3. J.E. Shigley, Uicker Jr., *Theory of Machines and Mechanisms*, (4e), McGraw Hill International, 2015.
4. R.L. Norton, *Kinematics and Dynamics of Machinery*, McGraw-Hill Higher Education, 2017.

ME2103: THERMODYNAMICS [3 1 0 4]

Definition and concepts: Heat & Work; Zeroth Law of Thermodynamics; Thermodynamic Properties of Fluids: Mathematical and Graphical representation of data, Ideal gas and Vander Waals Equation of state, Compressibility chart, Mollier diagram, Steam Tables; First law of Thermodynamics: Applications to Non flow and flow processes; Second Law of Thermodynamics: Carnot principle, Absolute thermodynamic temperature scale, Clausius Inequality, Entropy, Calculation of entropy change, Principle of increase-in-Entropy, Entropy generation; Availability: Concept of Available Energy, Availability of closed & open systems, Irreversibility; Thermodynamic Relations: Maxwell relations, Tds relations, Joule-Thompson coefficient, Clausius-Clapeyron equation; Ideal Gas Mixtures: Amagat's and Dalton's model, Properties of ideal gas mixtures, Gibbs phase rule; Gas Power cycles: Air standard cycle- Otto, Diesel, Dual, Stirling, Ericsson, Atkinson and Brayton Cycles; Vapour Power Cycles: Simple Rankine cycle, Reheat and Regenerative cycles with open & closed feed water heater.

References:

1. P.K. Nag, *Engineering Thermodynamics,* (6e), McGraw Hill, 2017.
2. Y.A. Cengel and M A Boles, *Thermodynamics: An Engineering Approach*, (8e), McGraw Hill, 2015.
3. Y.V.C. Rao, *An Introduction to thermodynamics*, (2e), Universities Press (India) Private Limited, 2004.

ME2104: STRENGTH OF MATERIALS [3 1 0 4]

Engineering Statics review. Introduction to deformable body mechanics, Notion of stress and strain – normal and shear stresses and strains, concept of thermal strain and stress. Stress-strain diagram: Mechanical properties. Stress-strain relationship: concept of linear-elastic-isotropic materials and Hook's law. Stress and strain at a point: stress and strain tensors, symmetry of tensors, different state of stresses and strains: uniaxial, biaxial and triaxial. Concept of plane stress and plane strain, stress and strain transformations, Principal stresses and strains. Mohr's circle concept. Deformations in axial loaded

members. Bending of beams: shear force and bending moment diagrams, pure bending, normal and shear stresses in beams, deflection in beams. Torsion: torsional moment diagrams, torsion of circular members, maximum normal and shear stresses, angle of twist. Concept of strain energy. Theories of failures. Introduction to energy methods. Elastic stability.

References:

1. F.P. Beer, R.J. Johnson, J. Dewole and D. Mazurek, *Mechanics of Materials*, (7e), McGraw Hill, 2015.
2. S.B. Timoshenko, J.M. Gere J.M, *Mechanics of Materials*, (2e), CBS Publishers, 2006.
3. B.C. Punamia, A.K Jain, *Mechanics of Materials*, Laxmi Publications, 2006.
4. R.K. Bansal, *Strength of Material*, Laxmi Publications, 2007.
5. R.C. Hibbeler, *Mechanics of Material*, Pearson Education, Low Price Edition, 2007.

ME2130: COMPUTER AIDED DRAFTING AND DESIGN LAB [0 0 2 1]

Introduction to design process and drawings of CATIA. Review of sectioning, drawing standards, dimensioning and notes. Fasteners – screws, bolts and nuts. Assembly drawings with sectioning and bill of materials. Assembly of screw jack, plumber block and piston. Detailed part drawings from assembly drawings. Production drawings - limits, fits and tolerances, dimensional and geometric tolerances.

References:

1. K.L. Narayana, *Machine Drawing*, (2e), Wiley Eastern, 2009.
2. C. Jensen, J. Helsel and D. Short, *Engineering Drawing and Design*, (7e), McGraw-Hill Science, 2007.
3. CATIA online web Tutorials.

ME2131: STRENGTH OF MATERIALS LAB [0 0 2 1]

Izod and Charpy Impact testing; Rockwell Hardness Testing; Vicker's Hardness Test; Brinell Hardness Testing; Torsion Testing; Tensile Testing; Compression Testing; Shear Testing; Bending Test on UTM; Measurement of stress due to bending using strain gauges, Study of Fatigue Testing Machine.

References:

1. R. Subramanian, Strength of Material, (2e), Oxford University Press, 2010.
2. A.V.K. Suryanarayan, Testing of Materials, (2e), PHI, 1990.
3. Technical Teachers, Training Institute, Lab Manual of Strength of Materials, Oxford University press, 1983.

ME2170: SEMINAR [0 0 2 1]

Each student has to present a seminar, on any technical topic. The presentation time is a minimum of 30 minutes followed by a 10 minutes session for discussion/ question & answers; The seminar topic selected by the student must be approved by the authorized faculty of the department at least two weeks in advance; Each student has to submit to the department a seminar report at least three days before the day of seminar; Each student has to make the presentation with LCD projector.

EO2001: ECONOMICS [3 0 0 3]

Introduction: Definition, nature and scope of economics, introduction to micro and macroeconomics; Microeconomics: Consumer behaviour, cardinal and ordinal approaches of utility, law of diminishing marginal utility, theory of demand and supply, law of demand, exceptions to the law of demand, change in demand and change in quantity demanded, elasticity of demand and supply, Indifference curve, properties, consumer equilibrium, Price and income effect; Production: Law of production, production function, SR and LR production function, law of returns, Isoquant curve, characteristics, Isocost, producer's equilibrium; Cost and revenue analysis: Cost concepts, short run and long- run cost curves, TR, AR, MR; Various market situations: Characteristics and types, Break-even analysis; Macro Economics: National Income, Monetary and Fiscal Policies,Inflation, demand and supply of money, consumption function and business cycle.

References:

1. H.L Ahuja, Macroeconomics Theory and Policy, (20e)S. Chand Publication.
2. H.C. Peterson, Managerial Economics, (9e), 2012.

3. P.L. Mehta, Managerial Economics, Sultan Chand & Sons.
4. G.J. Tuesen, H.G. Tuesen, Engineering Economics, PHI.
5. J.L. Riggs, D.D. Bedworth, Sabah U Randhawa, Engineering Economics, Tata McGraw Hill.

MA2202: ENGINEERING MATHEMATICS- IV [2 1 0 3]

Special Functions: Series solutions of Bessel and Legendre differential equations, Recurrence formulae, generating functions and Orthogonal properties for Jn(x) and Pn(x). Probability, finite sample space, conditional probability and independence, Bayes' theorem, one dimensional random variable: mean and variance, Chebyshev's inequality. Two and higher dimensional random variables, covariance, correlation coefficient, regression, least square principle of curve fitting. Distributions: binomial, Poisson, uniform, normal, gamma, chi-square and exponential. Moment generating function, Functions of one dimensional and two dimensional random variables, Sampling theory, Central limit theorem and applications.

References:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 7(e), John Wiley & Sons, Inc., 2015.
2. P. L. Meyer*, Introduction to Probability and Statistical Applications*, (2e), Oxford and IBH Publishing, Delhi, 1980.
3. B.S. Grewal, *Higher Engineering Mathematics*, 43(e), Khanna Publishers, 2014.
4. R.V. Hogg and A.T. Craig, *Introduction to Mathematical Statistics*, (4e), MacMillan, 1975.

ME2201: METROLOGY [3 0 0 3]

Measurements & Measurement Systems: Measuring Standards. Methods of measurement, Static Characteristics of Instruments & measurement systems, Measurement of Pressure by Elastic pressure elements and McLeod gauge., Temperature, Strain, Force, Torque and Shaft work. Limits, Fits and Tolerances: Clearance, Interference and Transition fits, Types of tolerances, System of fits, Principle of interchangeability, Selective assembly approach, Hole basis and Shaft basis system. Gauges: Types of gauges, Taylor's principle for design of gauges. Measurement of Form Errors: Flatness, straightness and squareness measurement, Engineer's Square tester, Optical Square. Comparators. Screw Threads: Design principle and application. Surface Texture measurement: Principles of design and operation. Gear measurement: Gear terminology, Errors in gears, Composite Tooth thickness, Gear tooth Vernier Callipers, Constant chord method, Base tangent method, Geometric Dimension & Tolerances.

References:

1. A.K. Bewoor, V. Kulkarni, Metrology & Measurement, McGraw Hill Publication, 2012.
2. N.V. Raghavendra, L. Krishnamurty, Engineering Metrology & Measurements, Oxford Publications, 2013.
3. R.K. Jain, Engineering Metrology, Khanna Publishers, 1997.
4. A.K. Sawhney, Mechanical Measurement & Instrumentation, Dhanpat Rai & Co, 2002.
5. I.C. Gupta, Engineering Metrology, Dhanpat Rai Publications, 1997.

ME2202: FLUID MECHANICS [2 1 0 3]

Properties of Fluids: Introduction, Various properties, Newtonian and Non-Newtonian Fluids. Fluid Statics: Pressure and its measurement: Pressure gauge, Manometers, Pascal's law, Hydrostatic law: Forces on plane and curved surfaces, Centre of pressure; Buoyancy, equilibrium of submerged and floating bodies, metacentric height. Fluid Kinematics: Lagrangian and Eulerian description of fluid flow, Types of Fluid flow, Stream line, path line and streak lines, Continuity equation, Fluids subjected to Velocity and acceleration, Stream function, Velocity Potential function Fluid Dynamics: Euler's and Bernoulli's equation, Bernoulli's theorem, Applications of Bernoulli's equation Flow: Pipe flow: Darcy Weisback equation, Friction factor, Minor and major losses in pipe, power transmission in pipe flow. Dimensional Analysis: Basic and derived quantities, Similitude and dimensional analysis, Buckingham π – theorem, Non-dimensional parameters and its significance. Boundary layer concept: Boundary layer separation. Viscous flow: Laminar flow: circular pipe (Hagen Poiseuille's equation), Parallel Plates. Introduction to hydraulic machines.

References:

1. Frank M. White, *Fluid Mechanics*, (7e), Tata McGraw Hills Pub.,2011

2. P. N. Modi and Seth, *Fluid Mechanics*, (5e), Standard Book House Pub., 2002.
3. Yunus A. Cengel, John M. Cimbala, *Fluid Mechanics*, (3e), 2014.
4. A. K. Jain, *Fluid Mechanics Including Hydraulic Machines*, (12e), Khanna Publication, 2016
5. R. K. Bansal, *Fluid Mechanics and Hydraulic Machines*, (9e), Laxmi Publications, 2015.

ME2203: DYNAMICS OF MACHINES [3 1 0 4]

Static force analysis; inertia forces, dynamic force analysis, dynamically equivalent system, turning moment diagram, flywheels; working principle of governors, centrifugal governors, characteristics of governors, controlling force curve; principle of gyroscopic couple, stability of plane, ships and vehicles; balancing for rotating and reciprocating machines, balancing of inline engines; introduction to vibration, natural frequency, single degree of freedom- free and forced damped and undamped vibrations.

References:

1. A.K. Mallik, A. Ghosh, *Theory of Mechanism and Machines*, (3e), Affiliated East-West Press (P) Ltd., 2015
2. S.S Rattan, *Theory of machines*, Tata McGraw Hill, 2005.
3. S.S. Rao, *Mechanical vibrations*, (5e), Pearson, 2010.
4. J.E. Shigley, Uicker Jr., *Theory of Machines and Mechanisms*, (4e), McGraw Hill International, 2015.
5. R.L. Norton*, Kinematics and Dynamics of Machinery*, McGraw-Hill Higher Education, 2017.

ME2230: METROLOGY LAB [0 0 2 1]

Study of measuring instruments and gauges; Screw thread measurement using tool maker's microscope; Use of profile projector; Measurement of effective diameter of external screw threads using Screw thread micrometer and floating carriage micrometer; Use of comparators; Gear testing (Parkinson's and Gear roller tester); Radius measurement; Angle measurement; Sine bar; Demonstration of surface roughness measurement; Straightness measurement; Measurement using Interferometer; Temperature measurement using thermocouple.

References:

1. A.K. Bewoor, V. Kulkarni, *Metrology & Measurement*, McGraw Hill Publication, 2012.
2. N.V. Raghavendra, L. Krishnamurty, *Engineering Metrology & Measurements*, Oxford Publications, 2013.
3. R.K. Jain, *Engineering Metrology*, Khanna Publishers, 1997.
4. A.K. Sawhney, *Mechanical Measurement & Instrumentation*, Dhanpat Rai & Co, 2002.
5. I.C. Gupta, *Engineering Metrology*, Dhanpat Rai Publications, 1997.

ME2231: FLUID MECHANICS LAB [0 0 2 1]

Calibration of V- Notch, Calibration of Rectangular Notch, Calibration of Weirs, Determination of discharge through a Venturimeter, Determination of discharge through an Orifice meter, Determination of Friction Factor in flow through pipes, Verification of Bernoulli's principle, Characteristics and performance testing of Reciprocating Pump, Characteristics and performance testing of Multistage Centrifugal Pump, Characteristics and performance testing of Gear Oil Pump Characteristics and performance testing of Pelton Wheel, Characteristics and performance testing of Francis Turbine, Impact of Jet on flat vanes.

References:

1. Frank M. White, Fluid Mechanics, (7e), Tata McGraw Hills Pub.,2011
2. P. N. Modi and Seth, Fluid Mechanics, (5e), Standard Book House Pub., 2002.

ME2232: COMPUTER AIDED NUMERICAL METHODS LAB [0 0 2 1]

Introduction to User Interface of MATLAB, data files and types, basic mathematics operators, operation on matrix, writing and execution of script files, 2D Plots: Basic plotting functions, creation of plot, legends. 3D plots: creating Mesh and surfaces. Programming: flow control, writing functions, Loops and conditional statements, Functions. Symbolic Math in MATLAB: Calculus-numerical differentiation and integration, Matrix Iteration Methods, Eigen value problem, Linear Algebra, Roots of polynomials, Algebraic equations, differential equations, Fourier and Laplace Transforms, MATLAB Simulink.

References:

1. MATLAB User Manual
2. C.C. Steven, *Applied Numerical Methods*, McGraw-Hill, 2008

ME2270: PROJECT BASED LEARNING-I [0 0 2 1]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, Agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

BB0026: Organization and Management [3 0 0 3]

Meaning and definition of an organization, Necessity of Organization, Principles of Organization, Formal and Informal Organizations. Management: Functions of Management, Levels of Management, Managerial Skills, Importance of Management, Models of Management, Scientific Management, Forms of Ownership, Organizational Structures, Purchasing and Marketing Management, Functions of Purchasing Department, Methods of Purchasing, Marketing, Functions of Marketing, Advertising. Introduction, Functions of Personal Management, Development of Personal Policy, Manpower Planning, Recruitment and Selection of manpower. Motivation – Introduction, Human needs, Maslow's Hierarchy of needs, Types of Motivation, Techniques of Motivation, Motivation Theories, McGregor's Theory, Herzberg's Hygiene Maintenance Theory. Leadership - Introduction Qualities of a good Leader, Leadership Styles, Leadership Approach, Leadership Theories. Entrepreneurship – Introduction, Entrepreneurship Development, Entrepreneurial Characteristics, Need for Promotion of Entrepreneurship, Steps for establishing small scale unit. Data and Information; Need, function and Importance of MIS; Evolution of MIS; Organizational Structure and MIS, Computers and MIS, Classification of Information Systems, Information Support for functional areas of management.

References:

1. Koontz, Harold, Cyril O'Donnell and H. Weihrich, *Essentials of Management*, Tata McGraw Hill.
2. Robbins, Stephen P, and Mary Coulter, *Management*, Prentice Hall.
3. E. S. Buffa and R. K. Sarin, *Modern Production / Operations Management*, (8e), Wiley, 1987
4. H. J. Arnold and D. C. Feldman, *Organizational Behavior*, McGraw – Hill
5. K. Aswathappa, *Human Resource and Personnnel Management*, Tata McGraw Hill
6. William Wether& Keith Davis, *Human Resource and Personnel Management*, McGraw Hill.

ME3101: PRODUCTION TECHNOLOGY- I [4 0 0 4]

Introduction to Sand Casting, Special Casting Process Shell Mold Casting, Investment Casting, Die casting, Centrifugal Casting, CO2 Molding, Applications-Advantages-Disadvantages of above processes, Defects in casting, causes & remedies. Metal Joining processes: Principles of welding, soldering and brazing. Types of welding processes and welded joints. Heat Affected Zone in Welding, Minimization of HAZ. Metal Forming: Introduction to Metal Forming, Nature of plastic deformation, Hot and cold working, Strain hardening, Recrystallization and grain growth. Rolling: Principle, Types of rolling mills, Roll passes, Forces in rolling and power requirements. Extrusion: Basic extrusion process - Types. Forging: Principles of forging, Tools and dies, Types: Smith forging, Drop Forging, Forging hammers, Rotary forging, Forging defects, causes and remedies, Wire Drawing. Sheet Metal Forming: Spring back effect, Stamping, Blanking, Bending, Drawing, Piercing, Coining, Embossing, Stretch forming. Processing of Plastics: Types of Plastics, Properties and applications, Processing Methods & Equipment (Blow & Injection Molding).

References:

1. S. Kalpakjian and S.R. Schmid, *Manufacturing Engineering and Technology*, (6e), Pearson Education, 2009.
2. A. Ghosh, and A.K. Malik, *Manufacturing Science*, (2e), Affiliated East West Press Pvt. Ltd., 2010.
3. P.C. Sharma, *A text book of Production Technology*, (4e), S. Chand and Company, 2006.
4. R.K. Jain, *Production Technology: Manufacturing Processes, Technology and Automation*, (17e), Khanna Publishers, 2011.

ME3102: DESIGN OF MACHINE ELEMENTS [3 1 0 4]

Design for strength: Review of theories of failures, Static loading, Allowable stress, Factor of safety, Stress concentration factor, curved beam, Design for fluctuating load. Riveted joints: Structural joints of lap & butt types, Rivets joints subjected to eccentric loading. Welded joints: Types of welding joints and symbols, Strength of welded joints and Design principle. Eccentric loading in welded joint. Shafts - ASME code equations for design of transmission shafts, design of shafts subjected to combined load. Design of Flexible Mechanical elements: Introduction, design of flat belt and V- belt. Gear design: introduction, Gear materials, load analysis on gear tooth, Contact Ratio, Stresses on gears. Key and couplings design.

References:

1. J.E. Shigley, C.R. Mischke, *Mechanical Engineering Design*, (7e), McGraw Hill Publication, 2003.
2. R.L. Norton, *Machine Design-An Integrated Approach*, (5e), Pearson Publisher, 2013.
3. U.C. Jindal, *Machine Design*, (1e), Pearson publisher, 2010.
4. V.B. Bhandari, *Machine Design Data book*, McGraw Hill Publication, 2014.

ME3103: HEAT & MASS TRANSFER [3 1 0 4]

Introduction, modes of heat transfer. Conduction, Fourier law, 3-D heat conduction equation, one dimensional steady state heat conduction in simple geometries – plane wall – cylinder and sphere. Critical thickness of insulation, internal heat generation, heat transfer from extended surfaces, unsteady state heat conduction. Convection: Concept of boundary layer theory, empirical correlation for free & forced convection, laminar and turbulent flow over a flat plate, flow over cylinders, spheres, bank of tubes. Radiation: thermal radiation, laws of radiation, Black and Grey bodies. Shape factor, radiation exchange between surfaces, Radiation shields, Greenhouse effect. Heat exchangers: Classification of heat exchangers, overall heat transfer coefficient, concept of fouling factor, Analysis of heat exchanger by using LMTD and NTU. Boiling and Condensation: pool boiling regimes, critical heat flux, flow boiling correlations, filmwise and dropwise condensation. Mass transfer: Introduction; Fick's law of diffusion, analogy between heat and mass transfer.

References:

1. J.P. Holman, Souvik Bhattacharyya, *Heat Transfer*, (10e), Tata McGraw Hill, 2011.
2. Y.A. Cengel and A J Ghajar, *Heat and Mass Transfer*, (5e), McGraw Hill, 2016
3. F.P. Incropera and D.P. Dewitt, *Fundamentals of Heat and Mass Transfer*, (7e), Wiley, 2012.
4. D S Kumar, *Heat and Mass Transfer*, (9e), Kataria and Sons, 2017.

ME3104: INTERNAL COMBUSTION ENGINE [3 0 0 3]

History of IC engines, Nomenclature, Classification, Comparison. Actual cycles. Testing & Performance, Emission Measurement, Conventional Fuels, Additives. Introduction of Alternative Fuels: Preparation, Engine performance, Combustion in CI & SI engines, Ignition Limits, Stages of combustion, Combustion parameters. Delay period and Ignition Lag, Turbulence and Swirl, Detonation & knocking, Theories of detonation. Combustion chamber. Engine Systems & Components: Fuel System, Injection systems, Ignition system, engine Friction & Lubrication, engine cooling. Supercharging & Turbocharging. Scavenging, Dual & Multi fuel engines: Principle, fuels, Combustion, performance Advantages, Modification in fuel system. Special Engines: Working principles of Rotary, Stratified charge, Free piston, Variable compression ratio engines.

References:

1. J. B. Heywood, *Introduction to Internal Combustion Engines*, (2e), McGraw Hill Publication, 2018.
2. V . Ganeshan, *Internal Combustion Engine*, (4e), McGraw Hill Publication, 2017.
3. C. Ferguson, *Internal Combustion Engines*, (2e), John Wiley & Sons, 2016.
4. R. Stone, *Introduction to Internal Combustion Engines*, (4e), The McMillan Press, 2012.

ME3130: PRODUCTION TECHNOLOGY - I LAB [0 0 2 1]

Practice of foundry operations, preparation of green sand mold, testing, and casting. Smithy operation and temperature measurement, Experiments on die casting machine and testing using ultrasonic flaw detector. Welding Practice: Preparation of welding joints by gas welding and arc welding, spot welding, TIG and MIG welding.

References:

1. S.K. Chaudhury and S.K. Hajara*, Elements of Workshop Technology Vol.1*, (14e), Media Promoters & Publishers Pvt. Ltd., 2010.
2. B.S. Raghuvanshi, *A course in Workshop Technology Vol.1*, (4e), Dhanpat Rai & Sons, 2014

ME3131: HEAT & MASS TRANSFER LAB [0 0 2 1]

Calibration of thermocouple Thermal conductivity of metal rod; Heat Transfer Through Composite Plane Walls; Heat transfer through Lagged pipe; Thermal conductivity of Insulating Material; Heat Transfer in Pin Fin; Heat Transfer in Force Convection apparatus; Heat Transfer in Natural Convection; Shell and Tube heat Exchanger; Emissivity Apparatus; Stefan Boltzman Apparatus, Critical Flux, Unsteady state heat transfer, Drop and Film Condensation Apparatus

References:

1. M. Thirumaleshwar, *Fundamentals of Heat and Mass Transfer*, (1e), Pearson Publication, 2006.

ME3132: INTERNAL COMBUSTION ENGINE LAB [0 0 2 1]

Cut Sectional 4 Stroke 1 Cylinder Petrol Engine for valve timing diagram; Performance test and Heat balance analysis of 4 stroke 4 cylinder Diesel engine test rig with Electrical dynamometer; Evaluating friction power by Morse test rig; Four Stroke Four Cylinder Petrol Engine Test Rig With Electrical Dynamometer; Performance Test of 4 stroke 3 cylinder petrol engine test rig with (AC dynamometer) with heat balance sheet; Performance test and heat balance analysis of four stroke single cylinder CI engines test rig with DC generator; Performance test and Heat balance analysis of four stroke single cylinder CI engines test rig with rope brake dynamometer; Performance test and Heat balance analysis of four stroke single cylinder CI engines test rig with hydraulic dynamometer. Fire and flash point tests; calorific value of liquid and gaseous fuel.

References:

1. S. Domukundwar, C.P. Kothandaraman, *A course in Thermal Engineering*, Dhanpath Rai, 2013.
2. P.L. Ballaney, Internal Combustion Engines, (6e), Khanna Publication, 2007.

ME3170: PROJECT BASED LEARNING-II [0 0 2 1]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, Agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

ME3201: PRODUCTION TECHNOLOGY- II [3 0 0 3]

Mechanics of Metal Cutting, Methods of Machining, Types of Cutting Tools, Cutting tool materials, cutting fluids, Nomenclature of Single point cutting tool, Types of chips in machining process, Merchant's Theory, Tool wear and Tool life. Lathe: Introduction to Capstan and Turret lathe. Introduction to shaper, Planer &

Slotter. Milling: Mechanics of Milling, Types of Milling Machines and Milling Cutters, Types of Milling processes, Concept of Indexing Mechanism/Dividing Head. Hole Making Operations: Mechanics of Drilling, Nomenclature of Twist Drill Bit, Types of Drilling Machines, Estimation of Machining time & Metal removal rate in Drilling operation. Finishing Operations: Mechanics of Grinding Operation, Specifications and Selection of Grinding Wheels. Lapping, Honing and Buffing, Broaching. Economics of metal machining.

References:

1. A. Ghosh, A.K. Malik, *Manufacturing Science*, (2e), Affiliated East West Press Pvt. Ltd., 2010.
2. P.N. Rao, *Manufacturing Technology Volume-2*, (4e), McGraw Hill Publication, 2013
3. S. Kalpajian, and S.R. Schmid, *Manufacturing Engineering and Technology*, (4e), Pearson Publication, 2002.
4. P.C. Sharma, *A text book of production technology*, (4e), S. Chand Publication, 2013.
5. R.K. Jain, *Production technology: Manufacturing Processes and Technology*, (17e), Khanna Publication, 2011.

ME3202: INTRODUCTION TO FINITE ELEMENT METHODS [3 1 0 4]

Introduction to FEM: Historical prospects, Applications, Commercial Software, Review of Matrix Algebra, Theory of Elasticity: Equilibrium equations, Stress-Strain relations, Compatibility equations, Plane stress and plane strain equations. Minimization of functional as solution of governing equations: Variational approach, Potential energy approach, Rayleigh Ritz methods, weak formulations and weighted residual (Galerkin method) methods. One Dimensional Elements: Bars- uniform, varying and Trusses. Beams. Stiffness matrix, force and displacement vectors and governing differential equations for such problems. 2-D element formulation, Constant Strain Triangle (CST) elements, Lagrange's Element formulations, Isoparametric elements.

References:

1. R.D. Cook, D.S. Malkus, M.E. Plesha and R.J. Witt, *Concepts and Applications of Finite Element Analysis*, (4e), 2002.
2. T.R. Chandrupatla, A.D. Belegundu, *Introduction to Finite Elements in Engineering*, (4e), PHI Learning Private Limited, 2011.
3. J.N. Reddy, *An Introduction to the Finite Element Method*, (3e), 2006
4. K.J. Bathe, Finite Element Procedures, (2e), 2007.

ME3203: REFRIGERATION AND AIR CONDITIONING [3 0 0 3]

Introduction to basic refrigeration cycles: Reverse Carnot cycle, Air refrigeration cycles, Air refrigeration cycles for aircrafts, Bell- Coleman cycle. Refrigerants and its properties, Ideal & Actual vapour compression cycle, Compound vapour compression refrigeration system, Multi evaporator and cascade systems, Ammonia absorption refrigeration, Lithium Bromide absorption system, Air Conditioning: Psychrometric properties and charts, Psychrometric of air conditioning process, Human comfort, thermal comfort, factors affecting thermal comfort, Effective temperature, comfort chart, Summer and winter air conditioning, Calculation of heating and cooling loads, Design of air conditioning systems.

References:

1. S.C. Arora and S. Domkundwar, *A Course in Refrigeration and Air-conditioning*, (3e) Dhanpat Rai, 2018.
2. N. Cook, *Refrigeration and Air conditioning*, (5e), Macmillan Education, 1995.
3. P.N. Ananthanarayanan, *Basic Refrigeration and Air conditioning*, (4e), McGraw Hill Education, 2013.
4. Rex Miller, Mark Miller, *Air Conditioning and Refrigeration*, (2e), McGraw Hill Education, 2011.

ME3204: COMPUTER INTEGRATED MANUFACTURING [3 0 0 3]

Introduction to NC machines, DNC Machine, CNC Machine, Part Programming, Maintenance, Economics of machining using CNC machines. Introduction to Computer Integrated Manufacturing Systems [CIMS]: Components, Types of Manufacturing Systems, Group Technology: Classification and Coding Systems. Computer Aided Process Planning: Rotational and prismatic parts, Material Requirement Planning [MRP], Manufacturing Resource Planning [MRP II], Capacity planning, Shop Floor Control, Introduction to FMS: AGV, AS/RS, Co-ordinate Measuring Machines [CMM], Universal Measuring Machine [UMM].

References:

1. K. Yoram, *Computer Control of Manufacturing Systems and Computer Integrated Manufacturing*, McGraw Hill Education, 1983.
2. M.P. Grover, *Automation, Production Systems and computer Integrated manufacturing*, (3e), Pearson International Edition, 2008.
3. Yoram, Ben and U. Joseph, *Numerical Control of Machine Tools*, Khanna Publishers, 2005.
4. P. Radhakrishnan, *Computer Numerical Control Machines*, (2e), New Academic Science Ltd., 2014.

ME3230: PRODUCTION TECHNOLOGY- II LAB [0 0 2 1]

Preparing turning Models by using Lathe. Exercises involving plain turning, step turning, knurling, chamfering, taper turning, facing, free hand turning and "V" & Square thread cutting. Demonstrations on eccentric turning, internal threading, and taper turning by taper turning attachment and tail stock set over method, Capstan and turret lathe etc., Milling Practice: Preparing milling models. Exercises on spur gear, helical gear, bevel gear, Slot milling; Shaping Practice: Preparing Shaping models. Shaping of flat surfaces, inclined surfaces, cutting of slots etc.; Grinding Practice: Exercises on Surface grinding and cylindrical grinding, Demonstrations on various advanced machines and machining operations.

References:

1. S.K. Chaudhury, S.K. Hajara, *Elements of Workshop Technology Vol.1*, (14e), Media Promoters & Publishers Pvt. Ltd., 2010.
2. B.S. Raghuvanshi, *A course in Workshop Technology Vol.2*, Dhanpat Rai & Sons, 2015.

ME3231: REFRIGERATION AND AIR CONDITIONING LAB [0 0 2 1]

Determine the COP and tonnage capacity of VCR test rig, Identification of performance of VCR unit using various types of expansion valve such as capillary expansion valve & thermostatic expansion valve. Performance of vapour absorption refrigeration system and comparison with VCR test rig. Determine the COP and tonnage capacity of Air-conditioner test rig. Study and determination of effectiveness of cooling tower and evaporative cooler, Study of psychrometric chart with different psychrometric process.

References:

1. C.P Arora, *Refrigeration and Air-conditioning*, (2e), McGraw Hill Education, 2006.

ME3232: COMPUTER AIDED ENGINEERING LAB [0 0 2 1]

Introduction to FEA, Demo and Practice of Typical FE Analysis, One-Dimensional Practice Problems, Problem of Stepped Bar, Truss Problems, Simply Supports Beam Problems, Other Beam Problems, Thermal Analysis, Modal Analysis, Additional Problems, Project based Problems, 2 Dimensional Problems and Viva Questions.

References:

1. ANSYS/ABAQUS user manuals
2. D.R. Cook, S.D. Malkus, E.M. Plesha and J.R. Witt, Concepts and Applications of Finite Element Analysis, (4e), 2002.

ME3270: PROJECT BASED LEARNING-III [0 0 2 1]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity

to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, Agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

ME4170: MINOR PROJECT [0 0 2 1]

The project work may be carried out in institute laboratory. The duration of the project work shall be 16 weeks. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, as part of project evaluation.

ME4171: INDUSTRIAL TRAINING [0 0 2 1]

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of sixth semester; the student has to submit to the department a training report in the prescribed format with a power point presentation followed by viva. The report should include the certificates issued by the industry.

ME4270: MAJOR PROJECT [0 0 0 12]

The project work may be carried out in an institution/ industry/ research laboratory. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, before the departmental committee, as part of project evaluation.

Program Elective:

ME3240: INDUSTRIAL ENGINEERING [3 0 0 3]

Introduction to Industrial Engineering, Scope, importance and applications of industrial engineering. Method study, Principle of motion economy, Techniques of method study - Various charts, THERBLIGS, Work measurement - various methods, time study, PMTS, determining time, Work sampling. Productivity - Definition, Various methods of measurement, Factors effecting productivity, Strategies for improving productivity. Statistical quality Control (SQC), Variables & Attributes, Production Planning & Control (PPC) : Introduction to Forecasting – Simple, Weighted moving average and exponential smoothing method, Aggregate planning, Master production schedule (MPS), Sequencing - Johnson algorithm for n-Jobs-2 machines, n- Jobs-3 machines, n-Jobs m-machines.

References:

1. S.N. Chary, Production & Operations Management, (4e), McGraw Hill Publication, 2009.
2. E. E. Adam, R. J. Ebert, Production and Operation Management: Concepts, Models, and Behaviour, (5e), Prentice Hall Publishers, 1992.
3. S.S. Buffa, Modern Production Management, (8e), John Wiley Publication, 2007.
4. P. Kumar, Industrial Engineering and Management, (1e), Pearson Publication, New Delhi, 2015.

ME3241: PRODUCTION AND OPERATIONS MANAGEMENT [3 0 0 3]

Introduction to production and operations management. Production and process design: Needs for product design and development, Product selection, modifying the existing products. Forecasting: Concept, Basic elements, Classification, Purpose of sales forecasting, Qualitative and Quantitative techniques of forecasting. Production planning and control: Nature, Types, Elements, strategy and aggregate production planning, production control-Loading and scheduling, Line of balance, Sequencing, Plant location and layout: Types of layout, Methodology of layout planning, Computer aided plant layout.

References:

1. W. J. S. Irwin, *Operation Management*, (9e), McGraw Hill Publication, 2005.
2. S. Paton, B. Clegg, J. Hsuan, and A. Pilkington, *Operations Management*, McGraw Hill Publication, 2011.
3. K. Aswathappa, S. Bhat, *Production and Operations management*, (2e), Himalaya Publication, 2015.

ME3242: PROJECT MANAGEMENT [3 0 0 3]

Introduction & objective of Project Management. Project life cycle, Project management as an integrated approach, Project manager and their attributes. Feasibility study, Estimating project times and costs, Top-down approaches of estimation, Bottom-up approaches of estimation, Hybrid approach of estimation. Risk management process, Contingency planning, Contingency funding and time buffers, Risk response control, change control management, Decision tree analysis, Numerical. Project scheduling: Bar charts and Milestone charts, Elements of network, Development of networks, Work Breakdown Structure (WBS), Critical Path Method, Program Evaluation and Review Technique, Network crashing, CPM updating, Numerical. Project audit and closure: Guidelines for conducting a project audit, Initiating and staffing, Data collection and Analysis, Audit reporting.

References:

1. C. Gray, E. Larson and G. Desai, *Project Management – The Managerial Process*, Tata McGraw Hill Pvt. Ltd., 2013.
2. R. Paneerselvam, P. Senthilkumar, *Project Management*, PHI Learning Pvt. Ltd., New Delhi, 2010.

3. J. Meredith, S. Mantel, *Project Management - A Managerial Approach*, John Wiley & Sons, USA, 2012.
4. N.D. Vohra, *Quantitative Techniques in Management*, New Delhi, 2007.

ME3243: MICROMACHINING [3 0 0 3]

Micromachining, Traditional Micromachining Processes, Materials for micromachining, Advanced Micromachining and Nanofinishing, Abrasive Water Jet Micromachining (AWJMM), Ultrasonic Micromachining (USMM), Abrasive Jet Micromachining (AJMM), Thermoelectric Advanced Micromachining, Electric Discharge Micromachining (EDM), Electric Discharge Grinding (EDG) And Electric Discharge Diamond Grinding (EDDG), Wire Electric Discharge Micromachining, Laser Beam Micromachining, Electron Beam Micromachining. Electrochemical and Chemical Advanced Machining, Chemical Micromachining (ChMM). Wafer bonding- Anodic bonding, Fusion bonding, CVD and PVD processes, Spin coating, Evaporation and Epitaxy, Laser ablation technique. Bulk and Surface Micromachining Techniques, Micromachining Tools.

References:

1. V.K. Jain, *Introduction to Micromachining*, Narosa Publishers,New Delhi, 2010.
2. V.K. Jain, *Advanced Machining Processes*, Allied Publishers Private Limited, New Delhi, 2009.
3. Mojtab Kahrizi, *Micromachining Techniques for Fabrication of Micro and Nano Structures*, Intech, 2012

ME3244: SOLAR ENERGY [3 0 0 3]

Solar Radiation: Basics, instruments for measuring solar radiation, solar radiation geometry, empirical equations, solar radiation on tilted surfaces. Liquid Flat plate Collector: Basic elements, performance analysis, transmissivity, absorptivity, heat transfer coefficients and correlations, collector efficiency and heat removal factors, effects of various parameters, Concentrating Collectors: Type of concentrating collectors and their general characteristics, geometry, heat transfer correlations, tracking requirements, performance analysis. Solar thermal power plants: Concentration and temperatures, parabolic geometries, paraboloid geometries (dish), heliostats, lay out, central receiver, Component design: Energy balance of components, design process and parameters, thermodynamic basis for receiver design, tube receiver concept. Thermal storage for solar power plants. Thermal Energy Storage: Basic methods, Sensible heat storage – liquids-solids-analysis, latent heat storage, thermo chemical storage, application of thermal storage. Performance analysis of miscellaneous solar applications: Solar Air heaters, solar pond, solar still, solar refrigeration.

References:

1. Soteris A. Kalogirou, *Solar Energy Engineering Processes and Systems*, (2e), Elsevier, 2014.
2. S.P. Sukhatme, *Solar Energy Principle of Thermal Collection and Storage*, (3e), Tata McGraw-Hill, 2015.
3. J. A. Duffie and W. A. Beckman, *Solar Engineering of Thermal Process*, (3e), John Wiley & Sons, 2000.
4. H.P. Garg and J. Prakash, *Solar Energy: Fundamentals and Applications*, (1e), McGraw-Hill, 2000.

ME3245: ADVANCED DESIGN OF MACHINE ELEMENTS [3 0 0 3]

Spring design: introduction and spring materials, design of Helical compression springs for static and fluctuating loads, multi-leaf springs. Design of Clutches, Brakes. Gear design: introduction, Gear manufacturing and Gear materials, design and load analysis of Helical, Bevel and Worm gear system. Rolling contact bearing: Introduction, bearing life, load life relation, reliability, selection of rolling contact bearings, mounting and enclosures. Sliding Contact Bearing: Types of journal bearings and lubrications, materials, hydrodynamic lubrication theory, design and selection of Hydrodynamic bearings. Design of Flexible Mechanical elements: introduction, design of V- belt and chain drives. Cylinders and Pressure vessels, Thin cylinder, Thick cylinder, Compound cylinders.

References:

1. J.E. Shigley, C.R. Mischke, *Mechanical Engineering Design*, (7e), McGraw Hill Publication, 2003.
2. R.L. Norton, *Machine Design-An Integrated Approach*, (5e), Pearson, 2013.
3. U.C. Jindal, *Machine Design,* (1e), Pearson, 2010.
4. V.B. Bhandari, *Machine Design Data book*, McGraw Hill Publication, 2014.
5. R.C. Juvinall, K.M. Marshek, *Machine Component Design*, (6e), Willey India Private Limited, 2017.

ME4140: INDUSTRIAL TRIBOLOGY [3 0 0 3]

Introduction to Tribology, Engineering surfaces, surface contact, adhesion. Causes of friction, friction theory, laws of rolling friction, friction of non-metallic material. Introduction, adhesive wear, abrasive wear, corrosive wear, wear analysis. Importance of lubrication, boundary lubrication, mixed lubrication, full fluid film lubrication, Elasto-hydrodynamic lubrication, types and properties of lubricants, lubricants additives. Fluid mechanics concepts, equation of continuity and motion, Generalized Reynold's equation with compressible and incompressible flow. Rolling contact bearing, sliding contact bearing, gears.

References:

1. G.W. Stachowiak, A.W. Batchelor, *Engineering Tribology*, (3e), Elsevier Inc., 2005.
2. J. Halling, *Principles of Tribology*, The Macmillan Press Ltd, 1975.
3. P. Sahoo, *Engineering Tribology*, PHI, 2005.
4. K.C. Ludema, *Friction, Wear, Lubrication: A textbook in Tribology*, CRC Press, 2010.
5. B. Bhusan*, Introduction to tribology*, (2e), Wiley, 2013.

ME4141: ROBOTICS [3 0 0 3]

Introduction: Definition of Robots, Types of Robots, Degrees of Freedom, Degrees of Movements, Robot Configuration, Definition and factor affecting the Control Resolution, Spatial Resolution, Accuracy and Repeatability; Specification of a robot; MTBF; MTTR; Actuators & Sensors in Robot, Rapid Review of Kinematics: Homogeneous Transformations, Forward and Inverse Kinematics, Jacobians. Dynamics: Euler-Lagrange Equations of Motion, Properties of Robot Dynamics, Examples. Independent Joint Control: Actuator Dynamics, PI/PID Control, Drive-Train Dynamics, Feedforward Control, Multivariable Control: Inverse Dynamics, Passivity-Based Robust and Adaptive control, Robot trajectory Planning.

References:

1. Craig, J. John, *Introduction to robotics: mechanics and control*, 3/E. Pearson Education India, 2009.
2. R.K. Mittal, I.J. Nagrath, *Robotics and control*, Tata McGraw-Hill, 2003.
3. Schilling, J. Robert, *Fundamentals of robotics: analysis and control. Vol. 629,* Prentice Hall, 1990.
4. K. Yoram, *Robotics*, McGraw Hill Publications, 1992.

ME4142: COMPUTER AIDED DESIGN [3 0 0 3]

Introduction to CAD, Geometric transformation techniques, Representation of curves, curve fitting techniques, Cubic curves, Beziers and b-splines, Hermite curve, Rational curves\NURBS. Types and representation of surfaces, Analytic surfaces, Synthetic types, Polygon surfaces, Quadric and super quadric surface, Bezier and B-spline surface, Hermite surface, Coon's surface, Blobby objects. Solid Modeling: Constructive solid geometry, Boundary representation, CAD standards, Graphical kernel system (GKS), Data exchange standards for modelling data.

References:

1. Zeid, R. Sivasubramanian, *CAD/CAM Theory and Practice*, Tata McGraw Hill New Delhi, 2009.
2. D.F. Rogers, J.A. Adams, *Mathematical Elements for Computer Graphics*, (2e), Tata McGraw Hill, 2017.
3. D.F. Rogers, J.A. Adams, *Procedural Elements for Computer Graphics*, (2e), McGraw Hill, 1997.
4. I. Zeid, *Mastering CAD/CAM*, (2e), McGraw Hill, 2006.

ME4143: INTRODUCTION TO MICRO ELECTRO MECHANICAL SYSTEMS [3 0 0 3]

Introduction to miniaturization, overview of micro-electromechanical systems, scaling analysis, sand to wafer, wafer level processing: RCA clean, Oxidation, Ion implantation, Physical vapour deposition, chemical vapour deposition, Epitaxy, sol-gel method, spin coating, Photolithography, Etching (Chemical and physical), Deep Reactive Ion Etching, Bulk micromachining, Surface Micromachining, LIGA, Micro sensors: Pressure sensor, gyroscope, accelerometer etc. Micro actuators: Electrostatic micro-comb drives, Piezoelectric, Shape Memory alloys etc., Metrology, Microfluidics, Process Modelling and case studies of process models of micro cantilever, micro hinges, micro pressure sensors, transistors, gates, micro-robots, mechanical packaging of microelectronics, assembly of microsystems, packaging materials, Introduction to COMSOL, Modelling of MEMS using COMSOL, RF MEMS.

References:

1. Tai-Ran Hsu, *MEMS and Micro systems Design and Manufacture*, (1e), Tata McGraw Hill, 2002
2. Nitaigour P. Mahalik, *Micromaufacturing and Nanotechnology*,(1e), Tata McGraw Hill, 2007
3. Marc Madou, *Fundamentals of Microfabrication*, (1e), CRC Press, 2002.
4. Chang Liu, *Foundation of MEMS*, (2e), Pearson Education Inc., 2006
5. G.K. Ananthsuresh, *Micro and Smart Systems*, (1e), Wiley, India, 2010.

ME4144: AUTOMATIC CONTROL ENGINEERING [3 0 0 3]

Concepts: Simple open and closed loop systems, concept of feedback, block diagrams, transfer functions. Representation of Control Components and Systems Representation, System Responses: Damping ratio and natural frequency, First order and second order system response to step input, Ramp input and sinusoidal input, response of a system to external disturbance, Frequency Response: Polar and rectangular plots for the frequency response, graphical view point, System Analysis using logarithmic plots, Bode diagrams: Stability analysis using Bode diagrams, simplified Bode diagrams System Analysis using Root locus Plots, Root Locus plots for simple transfer functions, graphical relationships setting the system gain, system transient response, system frequency response, System compensation, Digital Computer Control, State Space Analysis of Control Systems.

References:

1. K. Ogata, *Modern Control Engineering*, (5e), Pearson Publication, 2015.
2. S.N. Verma, *Automatic Control Systems*, Khanna Publishers, 1990.
3. F.H. Raven, *Automatic Control Engineering*, (5e), McGraw Hill Publication, 2013.

ME4145: COMPUTATIONAL FLUID DYNAMICS [3 0 0 3]

Introduction to CFD: Objectives of the course, motivation, course plan, evaluation method, references, Introduction to models of flow, laws of physics, derivations of Continuity, Momentum and Energy equations in Cartesian coordinate system, Transformation of these equations from Non conservative form to conservative; Initial and boundary conditions: One-way and two-way co-ordinates, Discretization Process-concept and structure, Methods of deriving the discretised equations, Explicit Taylor series expansion, Implementation of boundary conditions, The Four basic rules in control volume formulation. The derivation of the pressure correction equation as Poisson's Pressure equation, Implementation of boundary conditions in CFD. Grid generation using algebraic and partial differential equations; N-S equations in irregular geometry: transformation of N-S equation in curvilinear coordinate system, non-orthogonal grid.

References:

1. J.D. Anderson Jr., *Computational Fluid Dynamics- The Basics with Applications, (6e)*, International Edition, McGraw Hill, 2017.
2. H.K. Versteeg, W. Malalasekera, *An Introduction to Computational Fluid Dynamics-The Finite Volume Method,* (2e), Longman Scientific & Technical, 2007.

3. K.Muralidhar, T.Sundararajan, *Computational Fluid Flow and Heat Transfer,* (2e), Narosa Publishing House, 2009.
4. B. Andersson, R. Andersson, L. Hakansson, M. Mortensen, R. Sudiyo, B. V. Wechen, *Computational Fluid Dynamics for Engineers,* (1e), Cambridge Press, 2011.

ME4146: POWER PLANT ENGINEERING [3 0 0 3]

Concept and types of Power plant, Site selection, Steam Generators, Mountings and Accessories, Steam and heat rate, Steam turbine, Steam power plant, Rankine cycle improvisation, Layout, Components, Coal and ash handling systems, Draught system, Feed water system, Combined cycles power generation and Cogeneration systems. Diesel and Gas Turbine Plant: Components. Nuclear Power Plants: Location, Components of nuclear plants, types of Reactors, Uranium Enrichment, Safety, Disposal of nuclear waste, Comparison with thermal power plants, Safety measures for nuclear power plants. Hydro-electric power plant: Classification, Components and auxiliaries. Major hydro plants in India. Power plant economics, Power tariff types, Load distribution parameters, Load curves. Pollution control.

References:

1. P.K. Nag, *Power Plant Engineering*, (5e), McGraw Hill, 2018.
2. S. Domkundwar, *Power plant Engineering*, (8e), Dhanpat Rai, 2016.
3. M.M. El-Wakil, *Power Plant Technology*, (1e), McGraw Hill Education, 2002.

ME4147: NONCONVENTIONAL MANUFACTURING PROCESS [3 0 0 3]

Rapid Prototyping (RP): Subtractive and Additive Processes, Fused Deposition Modeling, Stereo lithography, laminated object manufacturing and three dimensional printing. Advanced Casting Processes, Advance Welding Processes. Process principles, equipment, applications, advantages and disadvantages of Abrasive Jet Machining (AJM), Water Jet Machining (WJM). Abrasive Water Jet Machining (AWJM), Ultrasonic Machining (USM). Electro Chemical Machining (ECM) Electro Chemical Grinding, Shaped Tube Electrolytic Machining (STEM), Electrical Discharge Machining (EDM), Wire EDM, Electrical Discharge Grinding (EDG), Chemical Machining (CHM), Photo chemical machining. Laser Beam Machining (LBM), Plasma Arc Cutting (PAC), Electron Beam Machining (EBM), Ion Beam Machining (IBM) and Thermal Energy Method (TEM). Introduction to Hybrid and Micro Machining Processes.

References:

1. G.F. Benedict, *Non Traditional Machining Techniques*, Marcel Decker, 1990.
2. E.J. Weller, *Non-Traditional Machining*, Society of Manufacturing Engineers, Dearborn, 1984.
3. P.K. Mishra, *Non-Conventional Machining*, Narosa Publishing.
4. K. Cooper, *Rapid Prototyping Technology: Selection and Application (Mechanical Engineering)*, (1e), CRC Press, 2001.
5. A.K. Kamrani, E.A.Nasr, *Engineering Design and Rapid Prototyping*, Springer, Boston, 2010.

ME4148: HEAT TREATMENT [3 0 0 3]

Iron carbon phase diagram, Time temperature transformation (TTT) and Continuous cooling transformation (CCT) diagram, Characterization of various microstructures. Introduction: Heat Treatment Processes: Annealing- its types and effect on mechanical properties, Hardening, Quenching, Tempering, Surface hardening techniques: flame hardening, induction hardening, laser beam hardening, electron beam hardening, Carburizing and its types, Nitriding, Ionitriding, Ion-carburizing, carbo-nitriding, plasma nitriding, Boronizing & Chromizing, Hardenability,. Elements of heat treatment process including heating rate determination and characteristics of heat treating furnaces, finishing operations, Heat treatment of tools, Heat treatment used to increase strength, Heat treatment and application of Non-ferrous metals and alloys.

References:

1. T.V. Rajan, C.P. Sharma and A. Sharma, *Heat treatment principles and techniques*, (2e), Prentice Hall Publishers, 2010.
2. W. Bolton, *Engineering materials technology*, (3e), Heinmann Newness, 2001.
3. B. Zakharov, *Heat treatment of Metals*, (1e), Mir Publishers, 2002.
4. K.E. Thelning, *Steel and its heat treatment*, (2e), Oxford Publication, 2013.
5. R.C. Sharma, *Principles of Heat Treatment of Steels*, New Age International (P) Limited, 2010.

ME4149: TOOL ENGINEERING [3 0 0 3]

Fundamental of Tool design practice, procedure of tool design, Nomenclature systems of single point cutting tools Design of single point cutting tools, design of milling cutters, gear milling cutters, hobs gear shaping tools, broaches, drill bits, reamers, taps & dies for thread cutting, boring tools, flat form tools, circular form tools. Essential requirements of jigs & fixtures, economics of jigs and fixtures, principles of location and clamping, location and clamping devices, types of drill bushes, types of jigs and fixtures- such as fixtures for milling, welding, heat treatment, grinding, assembly and inspection processes; standardization in jigs and fixtures, principle of work holders, common work holders for production like vice, chuck, arbor, mandrel & collet.

References:

1. B.L. Juneja, G.S. Sekhon, *Fundamentals of Metal Cutting and Machine Tools*, New Age International (P) Ltd., 1995.
2. Shaw M. C., *Metal Cutting Principles*, Clarendon Press, Oxford, 1996.
3. G.R. Nagpal, *Tool Engineering & Design*, Khanna Publishers, 2013.
4. P.H. Joshi, *Jigs and Fixture*, Wheeler Publishing, 1996

ME4150: OPERATION RESEARCH [3 0 0 3]

Classification of optimization, design vector and constraints, objective function, Classical Optimization Techniques: Single variable, and multi-variable optimization, direct substitution method, Linear Programming: Statement of an LP problem, graphical, simplex, Transportation method, Assignment Method. Job sequencing method, Theories of Decision Making, Queuing, Game Theory. Network Models: Critical Path Method, Project Evaluation and Review Technique (PERT). Introduction to Non-linear Programming.

References:

1. S.S. Rao, *Engineering Optimization: Theory and Practice,* (3e), New Age International Publishers, 2013.
2. H.A Taha, *Operations Research; An Introduction*, (9e), Pearson Publication, 2014.
3. K. Deb, *Optimization for Engineering Design Algorithms and Examples*, (2e), Prentice Hall Publishers, 2012.
4. J.C Pant*, Introduction to Optimization techniques*, (7e), Jain Brothers, 2008.

ME4151: DESIGN OF MECHANISM [3 0 0 3]

Introduction to kinematics and mechanisms: Motion, The Four-Bar Linkage, Relative Motion, Kinematic Diagrams, Six-Bar Chains, Degrees of Freedom, Analysis versus Synthesis. Introduction to kinematic synthesis: Graphical and linear analytical methods: Introduction, Tasks of Kinematic Synthesis, Type Synthesis, Tools of Dimensional Synthesis, Prescribed Positions. Graphical Synthesis: Motion Generation: Three Prescribed Positions, Graphical Synthesis for Path Generation: Three Prescribed Positions, Path Generation with Prescribed Timing: Three Prescribed Positions Graphical Synthesis for Path Generation (without Prescribed Timing): Four Positions Function Generator: Three Precision Points. Analytical Synthesis: The Standard Dyad Form, Number of Prescribed Positions versus Number of Free Choices, Three Prescribed Positions for Motion, Path. And Function Generation, Three-Precision-Point Synthesis Examples, Circle-Point and Centre-Point Circles.

References:

1. R.L. Norton, *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines*, (5e), McGraw Hill, 2011.
2. A.G. Erdman, G.N. Sandor and S. Kota, *Mechanism Design: Analysis and Synthesis*, (4e), Pearson, 2001.
3. K.J. Waldron, G.L. Kinzel, *Kinematic, Dynamics, and Design of Machinery*, (2e), Wiley and Sons, 2004.

ME4152: ELECTRIC VEHICLE TECHNOLOGY [3 0 0 3]

Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles:- Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle, Energy Management Strategies, Automotive networking and communication, EV and EV charging standards, V2G, G2V, V2B, V2H. Business: E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges, Connected Mobility and Autonomous Mobility- case study E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. Simulations and case studies in above mentioned areas.

References:

1. A. Emadi, J. Miller, M. Ehsani, *Vehicular Electric Power Systems*, CRC Press, 2003.
2. I. Husain, *Electric and Hybrid Vehicles*, CRC Press, 2010.
3. Larminie, James, and John Lowry, *Electric Vehicle Technology Explained*, John Wiley and Sons, 2012.
4. Tariq Muneer, Irene Illescas García, *The automobile, In Electric Vehicles: Prospects and Challenges*, Elsevier, 2017.
5. Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.

ME4153: ELEMENTS OF MECHATRONICS SYSTEMS [3 0 0 3]

Introduction of mechatronic systems, needs and benefits of mechatronics in manufacturing, Sensors and Transducers: Displacement Sensor, Strain gauges, Force/Torque, Motion & Velocity sensors, Proximity and Range sensors, ultrasonic sensor, Light sensors, Flow sensors, tactile sensors, Drives and Actuators: relays, DC motor, Servo motor, BLDC Motor, stepper motors, Hydraulic & Pneumatic actuators, Data Acquisition & Translation: Signal conditioning, Multiplexer, Pulse width Modulation, Linearization of data, Signal Averaging, Data Presentation System: Display - oscilloscope, LCD, Printers, Magnetic Recording. Controllers and Algorithms: PID controller.

References:

1. D.G. Alciatore, M.B. Histand, *Introduction to Mechatronics and Measurement systems*, (4e), McGraw-Hill Education, 2011.
2. W. Boltan, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, (4e), Pearson Education, 2010.
3. Devdas Shetty & Richard Kolk, *Mechatronics System Design*, (2e), Cengage Learning, 2010.
4. Dan Nesculescu, *Mechatronics*, (1e), Pearson Education Pvt. Ltd, 2002.
5. D.A. Bradley, *Mechatronics: Electronics in Products and Processes*, (2e), Nelson Thornes, 2004.

ME4154: NON-CONVENTIONAL ENERGY SYSTEMS [3 0 0 3]

Introduction: Different forms, Sources, Need for renewable energy sources, Solar energy: Solar radiation at the earth's surface, Measurement of solar radiation, solar radiation geometry. Solar air heaters, Cooking, Drying, Distillation, Space heating, Refrigeration, Power generation: Low, medium and high temperature cycle, Wind power: Total and maximum power (Betz theory), Actual power, Types of windmill, Wind turbine operation, Forces on the blades and thrust on turbines, Biomass: Types of biomass, Biogas production from organic waste by an aerobic fermentation, Conversion of energy: Thermal, chemical and electromagnetic energy into electricity, Introduction to Energy Storage. Miscellaneous sources of Non-conventional energy.

References:

1. S. P. Sukhatme, J.P. Nayak, *Solar Energy: Principles of Thermal Collection and Storage,* (3e), McGraw Hill India, 2009.
2. G.D. Rai, *Non-conventional Energy Sources,* (3e), Khanna Publications, 2004.
3. B. H. Khan, *Non-Conventional Energy Resources,* (3e), McGraw Hill Publications, 2017
4. S. Rao, B.B. Parulekar, *Energy Technology*, Khanna Publishers, 2004.

ME4155: ENERGY CONSERVATION, AUDIT AND MANAGEMENT [3 0 0 3]

Energy Conservation: Energy Scenario, Thermodynamic basis of energy conservation, Energy Conservation Act and policies, Energy conservation in HVAC systems and thermal power plants, Energy conservation in buildings and star ratings. Energy Audit: Definition, Energy audit-need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy audit instruments. Energy Management: Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy; Financial Analysis: Simple Payback, IRR, NPV, Discounted Cash flow.

References:

1. C.B. Smith, K.E. Parmenter, *Energy Management Principles*, (2e), Elsevier, 2015.
2. Albert Thumann, William J. Younger, *Handbook of Energy Audits*, (6e), The Fairmont Press Inc., 2003.
3. Frank Krieth, D. Yogi Goswami, *Energy Management and Conservation Handbook*, CRC Press, 2008.

ME4156: COMPOSITE MATERIALS [3 0 0 3]

Introduction to composite materials, Types of matrices & reinforcements, characteristics & selection, Fiber composites, laminated composites, particulate composites, prepregs, sandwich construction, Reinforcing fibres- Natural fibres, boron, carbon, ceramic glass, aramids, etc. Short and continuous fibre reinforced composites. Particulate fillers-importance of particle shape and size, Matrix resins-thermoplastics and thermosetting matrix resins. Coupling agents-surface treatment of fillers and fibres, significance of interface in composites, Fabrication techniques pultrusion, filament winding, prepreg technology, injection and compression moulding, resin transfer moulding, reaction injection moulding etc. Biocomposites, Nanocomposites, Micromechanics of composites. Properties and performance of composites. Applications, Mechanisms of fracture in composites, Property evaluation and NDT of composites.

References:

1. M. Schwartz, *Composite Materials handbook*, (2e), McGraw Hill Publication, 1992.
2. A.K. Kaw, *Mechanics of composite materials*, (2e), Taylor & Francis-India, 2010.
3. K.K. Chawla, *Composite material science and Engineering*, (3e), Springer, 2012.

ME4157: MATERIALS MANAGEMENT [3 0 0 3]

Concepts, evolution, importance and scope of materials management, organizational structure, man power planning, functions of management, principles of organisation, motivation, factors and techniques of

materials planning & budgeting and budgetary control, purchasing, purchasing policy, purchasing parameters and purchasing procedures. Strategic materials planning, JIT production planning, strategic materials planning, Criteria for make or buy decision, spare parts management including equipment selection, codification and standardization. Capital equipment planning and capital equipment decision and purchase of capital equipment's.

References:

1. S.C. Sharma, *Materials Management and Materials Handling*, Khanna Publishers, 2000
2. J.R.T. Arnold, S.N. Chapman and R.V. Ramakrishnan, *Introduction to Materials Management*, (5e), Pearson Education India, 2011
3. P. Gopalakrishnan, M. Sundareshan, *Material Management*, PHI Publications, 1999.
4. K. Datta, *Materials Management: Procedures, Text and Cases,* (2e), PHI Learning, 2008
5. A.K. Chitale, R.C. Gupta, *Materials management: Text and cases*, PHI Learning, 2013.

ME4158: SUPPLY CHAIN MANAGEMENT [3 0 0 3]

Introduction and objectives of supply chain, Decision phases in a supply chain, Purchasing tools and techniques, Value analysis, Project planning and control techniques, Pricing and revenue management, Costing fundamentals, Types of costing, Managing inventory in a supply chain, Economic order quantity, EOQ determination with instantaneous delivery and without shortages, Effect of quantity discount, safety stock, reorder level & lead time. Facility decisions in supply chain:, Factors influencing network design in supply chain, Models for facility location and capacity allocation, Transportation decisions in a supply chain, Routing and scheduling in transportation, Multistage transportation problems, Truck allocation problem, Travelling salesman problem, Vehicle routing problems, Financial evaluation of supply chain Decisions, The impact of financial factors on supply chain decisions, Discounted cash flow analysis, Evaluating supply chain decisions using decision trees.

References:

1. Chopra and Meindl, *Supply Chain Management – Strategy, Planning and Operation*, (3e), Pearson Education, 2009.
2. Raghuram and Rangaraj, *Logistics and Supply Chain Management: Cases and Concepts*, Macmillan, New Delhi, 2000.
3. Simchi-Levi and Kaminski, *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*, McGraw-Hill, 2003.
4. J. Shapiro, *Modelling the Supply Chain*, Duxbury Thomson Learning, 2009.
5. L.J. Krajewski and L.P. Ritzman, *Operations Management*, Pearson Education (Singapore) Pte. Ltd., 2005.

ME4159: PIPE SYSTEMS ENGINEERING [3 0 0 3]

Introduction: Definition and scope, Importance advantages of transport by pipeline, Piping elements. Codes and standards: ASME codes, Materials of construction, Pipe sizes. Single phase incompressible flow: Flow regimes, Development of velocity profile, Pressure drop calculations, Bernoulli's equation, Major and minor losses, Hydraulic and energy grade lines. Pipe networks: Pipe hydraulics and sizing, Pump and pipe system matching, H-Q curves, Pipes in series and parallel, Pipe network analysis. Structural design of pipe lines: Stress due to internal fluid pressure, Stress due to external fluid pressure, High/low pressure pipes. Planning and construction of pipelines: Piping drawing basics, Development of plot plan, Process piping layout, Utility piping layout, Selection of supports & expansion joints, Flexibility analysis. Protection of pipelines: Pipeline damage due to corrosion, abrasion, heating and freezing, Protection methods - Lining, coating, insulation, jacketing etc. Industrial pipelines: Non-Newtonian fluid flow, Single phase compressible flows - Flow analysis for ideal gas, flow analysis for real gas, Multi-phase flows – Slurry pipelines, Pneumotransport, Capsule pipelines.

References:

1. H. Liu, *Pipeline Engineering*, Lewis Publishers, CRC Press LLC, 2003.
2. G.A. Antaki, *Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair,* CRC Press, 2003.
3. B.E. Larock, R.W. Jeppson and G.Z. Watters, *Hydraulics of Pipeline Systems*, CRC Press LLC, 2000.
4. M.L. Nayyar, *Piping Handbook*, McGraw-Hill, 2000.

ME4160: ARTIFICIAL INTELLIGENCE & MACHINE LEARNING [3 0 0 3]

Introduction to Artificial intelligence and intelligent agents. Solving Problems by Searching, heuristic search techniques, constraint satisfaction problems, stochastic search methods. Game Playing: min-max, alpha-beta pruning. Propositional logic, first order logic, Uncertain Knowledge and Reasoning. Introduction to Machine Learning, Linear Regression and Feature Selection, Linear Classification, Support Vector Machines and Artificial Neural Networks, Bayesian Learning and Decision Trees, Clustering, Reinforcement Learning.

References:

1. Tom M. Mitchell, *Machine Learning*, (1e), McGraw Hill Education, 2017.
2. S.J. Russell, P. Norvig, *Artificial Intelligence: A Modern Approach*, (3e), Pearson Education India, 2015.
3. D.W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, (1e), Pearson Education India, 2015.
4. Yuxi (Hayden) Liu, *Python: Machine Learning by example*, (1e), Packt Publishing Limited, 2017.
5. P. Joshi, *Artificial Intelligence with Python*, (1e), Packt Publishing Limited, 2017

ME4161: PLANT LAYOUT AND MATERIAL HANDLING [3 0 0 3]

Principle of plant layout, product, process and combination layout, economics of different types of layout. Factors influencing the layout manpower, movement, service, material, machinery, waiting, building and change factors, location of storages & delay point. Layout planning scientific approach, flow process chart, cross chart, string diagram, line balancing, templates evaluation of layout, installation of layout, computerized layout planning. Material handling- principles of material handling, factors in selection of material handling equipment, safety in material handling, types of material handling equipment, modern material handling equipment.

References:

1. E.S. Buffa, S.K. Rakesh, *Modern Production and Operation Management*, John Wiley & Sons, 2003.
2. M. Richard, *Practical Plant Layout*, McGraw-Hill, 1955.
3. A.M. James, *Plant Layout and Material Handling*, John Wiley, New York, 1977.

ME4162: LEAN MANUFACTURING [3 0 0 3]

The production system, types, inception &necessity of lean production system, lean revolution in Toyota, basic image of lean production, Principles& Characteristics of Lean Manufacturing, MUDA(waste) and types, Lean Manufacturing Tools and Techniques, Cellular Manufacturing, Continuous Improvement, Just-In-Time, Production Smoothing, Overall Equipment Efficiency, standardized work and KAIZEN, Standardization of operations, Multi-function workers and job rotation, Improvement activities to reduce work force and increase worker morale foundation for improvements, Shortening of production lead times.

References:

1. L. Wilson, *How to implement Lean Manufacturing*, The McGraw Hill Companies, 2010.
2. W.M. Feld, *Lean Manufacturing Tools, Techniques, and How To Use Them*, CRC Press, 2000.
3. J.P. Womack, D.T. Jones and D. Roos. D, *The Machine that changed the World. The Story of Lean Production*, Harper Perennial, 2007.

4. N. Gopalakrishnan, *Simplified Lean Manufacture Elements, Rules, Tools and Implementation*, PHI, 2010.

ME4163: PRODUCTION PLANNING AND CONTROL [3 0 0 3]

Introduction: Functions of production, planning and control. Types of production activities, Production consumption cycle. Forecasting Analysis: Importance and uses of forecasting, Type of forecasts, Qualitative methods of forecasting, Quantitative methods of forecasting, Exponential smoothing, Linear regression analysis, Correlation analysis and Seasonality, Forecast control. Aggregate planning: Need and inputs for aggregate production planning, Pure and mixed strategies of aggregate planning. Aggregate planning approach. Job shop scheduling: Factors affecting job shop scheduling, Index method, Priority sequencing rules, Determination of mean flow time, average job lateness and average number of jobs in the system. Inventory control: Classification of inventories, Economic order quantity, Inventory control models, Effect of quantity discount, Safety stock, Reorder level, Lead time. MRP: Product structure tree, MRP inputs and outputs, MRP logic, Problems. Assembly line balancing.

References:

1. G.M. Joseph, *Operations Management*, Tata McGraw-Hill Publishing Co. Ltd., 2004.
2. L.J. Krajewski, P.L. Ritzman, *Operations Management*, Pearson Education (Singapore) Pte. Ltd., 2005.
3. E.E. Adam, R.J. Ebert, *Production and Operations Management*, Prentice Hall of India Pvt. Ltd., 2002.
4. R.B. Chase, N.J. Aquilano and F.R. Jacobs, *Production and Operations Management*, Tata McGraw-Hill Publishing Co. Ltd., 1999.
5. Eilon Samuel, *Elements of Production Planning and Control*, Universal Publishing Corporation, 1991.

ME4164: THERMAL STORAGE SYSTEMS AND ITS APPLICATIONS [3 0 0 3]

Thermal energy storage: principles and applications, sensible and latent heat storage systems, Sensible heating systems: Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; `Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage. Latent heat storage systems: Phase Change Materials (PCMs); Selection criteria of PCMs; Stefen problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. Energy and exergy analysis of thermal energy storage systems case studies. Applications: Active and passive thermal energy storage, Solar water/air heater, crop dryer, building space comfort.

References:

1. I. Dincer, M.A. Rosen, *Thermal Energy Storage Systems and Applications*, (2e), John Wiley & Sons Ltd, 2011.
2. S.P. Sukhatme, J.P. Nayak, *Solar Energy: Principles of Thermal Collection and Storage,* (3e), McGraw Hill India, 2009.
3. L.F. Cabeza, *Advances in Thermal Energy Storage Systems: Methods and Applications,* (1e), Woodhead Publishing Seriesin Energy, Elsevier Science and Technology, 2014.
4. H. Mehling, L.F. Cabeza, *Heat and cold storage with PCM-An up to date introduction into basics and applications,* (1e), Berlin Springer, 2008.

ME4165: ALTERNATIVE FUELS IN I.C. ENGINES [3 0 0 3]

Introduction: Need of alternative gaseous fuels, future automotive gaseous fuels, hydrogen, CNG, LNG, and Producer gas, biogas, LPG. Physical properties of different gaseous fuels, mode of engine operations, spark ignition and dual fuel mode, multi fuel mode, combustion and performance of engines, specific problems. Use of alcohol in four stroke S I & C I engines, use of alcohol in two stroke engines, use of bio diesels, combustion and performance of engines. Impact of alternative fuels on engine test, guidelines for emission measurements, emission norms for engines using alternative fuels. Legal aspects of blending

alternative fuels into conventional liquid fuels, properties of blends, comparison of neat versus blended fuels, fuel testing.

References:

1. J. B. Heywood, *Introduction to Internal Combustion Engines*, McGraw Hill Publication, 2011.
2. V. Ganeshan, *Internal Combustion Engine*, (4e), McGraw Hill Publication, 2012.
3. C. Ferguson, *Internal Combustion Engines*, (2e), John Wiley Publication, 2016.
4. R. Stone, *Introduction to Internal Combustion Engines*, (4e), McMillan Press, 2012.

ME4166: TURBOMACHINERY [3 0 0 3]

Basic Principles of Turbomachines; Classification, Energy Transfer in Fluid Machines, Euler's equation, Impulse and Reaction machines, Velocity triangles for radial and axial flow turbomachines. Centrifugal Gas Turbine; Thermodynamic Analysis. Various components of Gas Turbine and Propulsion systems, Cascade Theory, Axial Flow Turbine; Degree of Reaction, Calculation of Stage Efficiency and Turbine Performance. Gas Turbine Combustors, Steam Turbines, Flow through nozzles, Stagnation properties, sonic properties and isentropic expansion through nozzles, Isentropic Flow, Single-Stage Impulse Turbine, Compounding of the Impulse Turbine, Reaction Turbines, Stage Efficiency and Reheat factor. Centrifugal Compressor; Power input factor, Losses in Centrifugal Compressors, Compressor characteristics. Axial Flow Compressors; Surging and stalling of compressors, Compressor characteristics, Reciprocating compressors; principle and applications. Hydraulic Turbines; Pelton Wheel, Specific Speed, Governing, Limitation, Kaplan Turbine, Francis Turbine, Types of Draft Tubes, Cavitation, and Performance Characteristics, Comparison of Specific Speeds of Hydraulic Turbines. Hydraulic pumps.

References:

1. S. Dixon, *Fluid Mechanics and Thermodynamics of Turbomachinery*, (7e), Butterworth-Heinemann, 2014
2. S. M. Yahya, *Turbines, Compressors & Fans*, (2e), Tata-McGraw Hill Co., 2002.
3. P. W. William, *Fundamentals of Turbomachinery*, (1e), John Wiley & Sons, 2008.
4. M. S. Govindgouda, A. M.Nagaraj, *A Text book of Turbomechanics*, (4e), M.M. Publications, 2008.
5. B. K. Venkanna, *Fundamentals of Turbomachinery*, PHI, 2009.

ME4167: INTRODUCTION TO THEORY OF ELASTICITY [3 0 0 3]

Definition and Notation: Stress, Stress at a Point, Equilibrium Equations, Principal Stresses, Mohr's Diagram, Maximum Shear Stress, Boundary Conditions. Two Dimensional Problems: Cartesian co-ordinates – Airy's stress functions – Investigation of Airy's Stress function for simple beam problems – Bending of a narrow cantilever beam of rectangular cross section under edge load – method of Fourier analysis – pin ended beam under uniform pressure. General equations in cylindrical co-ordinates: Thick cylinder under uniform internal and / or external pressure. Stresses in an Infinite Plate: Stresses in an Infinite Plate (with a circular hole) subjected to uniaxial and biaxial loads, stress concentration. Torsion of Circular, Elliptical and Triangular Bars: Membrane analogy, torsion of thin open sections and thin tubes. Uniqueness Theorem: Principle of super position, reciprocal theorem, Saint Venant principle.

References:

1. M.H. Sadd, *Elasticity: Theory, Applications and Numerics*, (2e), Academic Press, 2009.
2. S. Timoshenko, J.N. Goodier, *Theory of Elasticity*, (3e), Tata McGraw Hill, 2017.

ME4168: INTRODUCTION TO FRACTURE MECHANICS [3 0 0 3]

Introduction: Historical perspective, Stress concentration effects of flaws, Fracture Mechanics approach to design, Effect of material properties on fracture, Damage tolerance. Linear Elastic Fracture Mechanics (LEFM): An atomic view of fracture, Stress concentration effect of flaws, Mathematical foundation of LEFM, The Griffith energy balance, The energy release rate, The path independent, J-, L-, and M-integrals, The Westergaard stress function, Stress analysis of cracks, The stress intensity factor, Relationship between K and G, Crack Tip Plasticity, The Irwin's approach, The strip yield model, comparison of plastic zone

correction, Plane stress vs Plane strain, K as a failure criterion, Effect of loading mode and specimen dimension. Introduction to Fracture Toughness Testing.

References:

1. T.L. Anderson, *Fracture Mechanics: Fundamentals and Applications,* (4e), CRC Press, 2017.
2. E.E. Gdoutos, *Fracture Mechanics: An Introduction*, (2e), Springer, 2006.

ME4169: MECHANICAL VIBRATION [3 0 0 3]

Introduction of Vibration: Types of Vibration, Single degree freedom system. Two-DOF Free Vibrations: Generalized and Principal coordinates, derivation of equations of motion, Lagrange's equation, Coordinate coupling. Multi-DOF: Influence coefficient method, Modal analysis: Undamped and damped, Matrix iteration method, Dunkerley's method. Torsional vibration: Holzer method and Geared system. Continuous systems: Vibration of strings, Longitudinal and torsional vibration of rods, Transverse vibration of beams. Finite element analysis: Finite element formulation for rods, Finite element formulation for beams, Modal Analysis with FEA

References:

1. S.S. Rao, *Mechanical Vibration*, (4e), Pearson Education, 2004.
2. W.T. Thomson, *Theory of Vibrations with Applications*, (5e), Pearson Education, 2008.
3. L. Meirovitch, *Elements of Vibration analysis*, McGraw-Hill, Singapore, 1986.

Open Elective:

ME2080: INTRODUCTION TO NANOTECHNOLOGY [3 0 0 3]

Basic concepts of Nanoscience and Nanotechnology; Nanostructures and different types of Nanomaterials: Basic structure of nanoparticles- kinetics in nanostructured materials- zero dimensional, size and shape of nanoparticles; one-dimensional and two dimensional nanostructures- clusters of metals, nanowires, semiconducting nanoparticles and bionano-particles. Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; metal nanocrystals by reduction, sol-gel synthesis, microemulsions or reverse micelles, myle formation, solvothermal synthesis, thermolysis routes, microwave heating synthesis, sonochemical synthesis, electrochemical synthesis, photochemical synthesis, synthesis in supercritical fluids. Fabrication of Nanomaterials by Physical Methods: Inert gas condensation, arc discharge, plasma arc technique, RF plasma, MW plasma, ion sputtering, laser ablation, laser pyrolysis, ball milling, molecular beam epitaxy, chemical vapour deposition method and electro deposition. Nanocomposites: An introduction: types of nanocomposite (i.e. metal oxide, ceramic, glass and polymer based), core-shell structured nanocomposites, superhard nanocomposite, Synthesis, applications and milestones. Characterizing Nanoparticles Analytical Technique; Toxicity and Safety of Nanomaterials: Environmental concerns of nanomaterials. Applications of Nanotechnology: Nanotechnology in medicine; nanotechnology for food, agriculture, livestock, aquaculture and forestry, nanotechnology for a sustainable environment.

References:

1. G.C.Y. Wane, *Nanostructures and Nanomaterials*, (2e), World Scientific Publishing, 2011.
2. C.P. Poole, F.J. Owens, *Introduction to Nanotechnology*, (1e), wiley india Pvt. Ltd, 2007.
3. T. Pradeep, *Nano: The essentials*, (1e), McGraw Hill Professional, 2008.
4. R. Kelsall, *Nanoscale Science and Technology*, (1e), John wiley & sons, 2005.
5. A.S. Edelstein and R.C. Cammarata, *Nanomaterials: Synthesis, properties and applications*, (1e), Institute of Physics, 1996.

ME2081: INTRODUCTION TO QUALITY CONTROL [3 0 0 3]

Definitions of the term quality, Patterns of variation, Causes of variation Frequency distribution, Measures of central tendency and dispersion, The Normal distribution curve, Inequality theorems, Shewhart's bowl drawing experiments, Control charts for variables (X , R and s charts), Type I and Type II Errors, Process capability analysis, Process capability indexes, Control charts for attributes (p ,np, c and u charts), Acceptance sampling by attributes, Single and Double sampling plans, Operating characteristic curve, Acceptable quality level, Lot tolerance percent defective, Average outgoing quality, Average total Inspection, Average fraction inspected, Producers risk, Consumers risk, Acceptance sampling tables, Conventional and Statistical tolerancing, Precision, Accuracy and Reproducibility of method of measurements, Quality costs.

References:

1. E.L. Grant, R. Levenworth, *Statistical Quality Control*, McGraw Hill Publications, 2005.
2. M.S. Mahajan, *Statistical Quality Control*, Dhanpat Rai and Co. Pvt. Ltd., 2012.
3. D.C. Montgomery, *Introduction to Statistical Quality Control*, John Wieley and Sons, 2005.
4. J.M. Juran, F.M. Gryna, *Quality Planning and Analysis,* Tata McGraw Hill Publications, 1995.
5. L. Bertrand Hansen, *Quality Control- Theory and Applications*, Prentice Hall India, 1987.

ME2082: ENGINEERING ECONOMICS [3 0 0 3]

Introduction to Economics: Micro & Macro, Value, Utility, Consumer and producer goods, Factors of production. Demand and its types, Law of demand & supply, Elasticities of demand, Equilibrium of demand & supply, Law of variable proportions. Interest factors for discrete compounding. Comparison of alternatives based on: Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Capital recovery with return, Rate of return method, Incremental approach. Evaluation of replacement alternatives involving sunk costs, Replacement analysis for unequal lives. Nature of public activities and their evaluation based on benefit: Cost analysis, Identifying benefits, Dis-benefits and costs. Break Even Analysis for single product, Depreciation and depletion meaning and its methods.

References:

1. P.L. Mehta, *Engineering Economics*, Sultan Chand & sons, 2013.
2. E.L. Grant, W.G. Ireson and R.S. Leavenworth, *Principles of Engineering Economy*, John Wiley, 1990.
3. L. Blank and A. Tarquin, *Engineering Economy*, (7e), McGraw Hill Education, 2011.
4. J.L. Riggs, D.D. Bedworth and S.U. Randhawa, *Engineering Economics*, (4e), McGraw Hill Education, 1996.

ME2083: QUALITY MANAGEMENT [3 0 0 3]

Evolution of Quality Control, concept change, Quality concept in design, Review of design, inspection and control of product, Costs of quality, 7QC tools, Statistical Quality Control (SQC), Control charts (X-R, P, C) for Variables & attributes, Process capability, Quality assurance systems, Quality in sales and services, Acceptance sampling, OC curve, Concept of AOQL, Sampling plan: Single, Double & sequential, Introduction to TQM: Quality gurus & ISO - 9000.

References:

1. D.C. Montgomery, *Introduction to Statistical Quality Control*, (6e), John Wiley & Sons Inc., 2008.
2. M. Mahajan, *Statistical Quality Control*, Dhanpat Rai, 2016.
3. E.L. Leavenworth, S. Richard and E.L. Grant, *Statistical Quality Control*, (7e), McGraw hill Education, 1972.
4. B.L. Hansen, P.M. Ghare, *Quality Control and Application*, (1e), Prentice Hall, 1987.

ME3080: WELDING TECHNOLOGY [3 0 0 3]

Introduction: Review of Conventional Welding Processes, Welding of Dissimilar Metals. Gas Welding Processes: Gas Welding Processes and Equipment's. Arc Welding Processes and Equipment's, Arc Mechanism, Heat and Temperature effect in Arc Welding, Fusion, Cooling and Solidification of weld metal, welding electrode specification. Resistance Welding Processes: Fundamentals of Heat and Pressure in Resistance Welding. Solid State Welding: Principle of operation and applications. Laser Beam and Electron Beam Welding processes and their applications. Special Welding Techniques: Underwater welding; welding of Pipelines and Piping, Welding Defects, Testing and Inspection.

References:

1. H.B. Cary, *Modern Welding Technology*, (3e), Prentice Hall Publishers, 1993.
2. P.T. Houldcroft, *Welding Process Technology*, Industrial Press Inc., 1998.
3. R.S. Parmer, *Welding Engineering & Technology*, Khanna Publishers, 1999.
4. V.M. Radhakrishnan, *Welding Technology and Design*, (2e), New Age International Pvt Ltd, 2005.

ME3081: MODERN MANUFACTURING [3 0 0 3]

Introduction: Trends in modern manufacturing; characteristics and classification of modern manufacturing methods, considerations in the process selection. Mechanical Processes: Introduction, principle, process

description, material removal mechanism, parametric analysis of USM, AJM, WJM and AWJM processes. ECM, ECG, Electrochemical honing and Chemical Machining processes. EDM, Wire EDM, LBM, EBM, PAM. Hybrid Machining Processes: Concept, classification, and applications of various hybrid machining methods based on USM, EDM, ECM, etc. Micromachining Processes.

References:

1. P.C. Pandey and H.S. Shan, *Modern Machining Processes*, Tata Mcgraw Hill, 2003.
2. S. Kalpakjian, *Manufacturing Engineering and Technology*, (4e), Addison Wesley Longman, 2002.
3. A. Ghosh, A.K. Malik, *Manufacturing Science*, (2e), Affiliated East West Press Pvt. Ltd., 2010.
4. P.K. Mishra, *Nonconventional machining*, Narosa publishing house, 2011.
5. V.K. Jain, *Introduction to micro machining*, (1e), Narosa publishing house, New Delhi, 2010

ME3082: PRODUCTION MANAGEMENT [3 0 0 3]

Production management system, its need and requirement, Production planning control, Various methods of forecasting, Aggregate planning, Master production scheduling-Types of scheduling and need for re-scheduling, Cost planning and control, capacity planning, Manufacturing Resource Planning, Inventory management, Material requirement planning (MRP),Working and benefits of different types of inventory system ,Performance measures ,Lot sizing methods, Just In Time, Pull and push system ,Kanban Shop floor Control, Enterprise Resource Planning (ERP)**.**

References:

1. S.N. Chary, *Production & Operations Management*, (5e), McGraw Hill Publication, 2017.
2. S.S. Buffa, *Modern Production Management*, (8e), John Wiley Publication, 2019.
3. E. E. Adam, R. J. Ebert, *Production and Operation Management: Concepts, Models, and Behaviour*, (5e), Prentice Hall Publishers, 1992.
4. P. Kumar, *Industrial Engineering and Management*, (1e), Pearson Publication, 2015.

ME3083: OPTIMIZATION IN ENGINEERING DESIGN [3 0 0 3]

Introduction to optimization, adequate and optimum design, formulation of objective function, design constraints. Classical optimization techniques: Single variable optimization, multivariable optimization with no constraints, exhaustive search, Fibonacci method, golden selection, Random, pattern and gradient search methods, Interpolation methods: quadratic and cubic, direct root method. Multivariable unconstrained and constrained optimization: Direct search methods, descent methods, conjugate gradient method. Indirect methods, Transformation techniques, penalty function method. Non-traditional optimization techniques: Genetic Algorithms, Particle Swarm Optimization Algorithm, etc. Optimum design of machine elements: Desirable and undesirable effects, functional requirement, material and geometrical parameters, Design of simple axial, transverse loaded members for minimum cost and minimum weight.

References:

1. S.S. Rao, *Engineering Optimization: Theory and Practice*, John Wiley & Sons, 1996.
2. K. Deb, *Optimization for Engineering Design*, Prentice Hall of India,2nd Edition, 2012.
3. J.S. Arora, *Introduction to Optimum Design*, Elsevier, Academic Press., 4th Edition, 2016
4. R.L. Fox, *Optimization Methods for Engineering Design*, Addison-Wesley Publication Co., 1971.

ME3084: RELIABILITY, AVAILABILITY AND MAINTENANCE ENGINEERING [3 0 0 3]

Introduction: Types of System; Series system; Parallel system; Series-Parallel System; Redundancy in Systems. Difference between System and Component: System and Component Reliability. Definition and concept; MTBF, MTTF, MTTR concept, Bathtub curve concept. Reliability in terms of Hazard rate, CDF,PDF; Repairable and Non-Repairable Systems; Reliability data and censoring Approaches; Probability Distributions and Distribution Models: Discrete and Continuous Distribution; Normal Distribution; Exponential Distribution; Weibull Distribution; Point, mission and steady state availability, Availability assessment. Maintainability and its assessment, design for reliability and maintainability.

References:

1. C.E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, McGraw Hill Publication, 2005.
2. S.S. Rao, *Reliability Engineering*, Pearson Publication, 2016.
3. K.C. Kapoor and L.R. Lamberson, *Reliability in Engineering Design*, John Wiley Publication, 2015
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ME3085: ENERGY ENGINEERING [3 0 0 3]

Introduction, global and Indian energy scenario. Current energy sources, Energy scarcity and reasons, Energy conversion techniques: conventional and direct energy conversion techniques, applications and limitations. Energy efficiency measures and energy conservation technologies. Non-conventional sources of energy, Renewable energy: solar energy technologies, solar radiation and collectors, solar photovoltaic systems, wind energy, bio-energy and hybrid-systems. Energy storage systems, need and importance. Role of energy engineering in cleaner and greener environment.

References:

1. Albert Thumann, *Handbook of Energy Engineering*, (5e), The Fairmont Press Inc., 2001.
2. Nick Jenkins and Janaka Ekanyake, *Renewable Energy Engineering*, (1e), Cambridge University Press, 2017.

ME3086: INDUSTRIAL SAFETY ENGINEERING [3 0 0 3]

Introduction to Safety Engineering, Industrial Accidents, Theories of Accident Causation, Introduction to Health and Toxic Substances, Environmental Control and Noise, Ventilation and its Design Principle, Personal Protection and First Aid, Fire Protection, Machine Guarding, Safeguarding the point of operation, Power presses, Grinding machines, Saws, Belts and Pulleys, Safety consideration regarding material handling and storage. Safety Requirement for Material Handling and Storage, Electrical Hazards, Employee Participation in Promoting Safety, Safety Training, Safety Committees, Teamwork Approach to Promoting Safety.

References:

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2. F.R. Spellman, N.E. Whiting, *The Handbook of Safety Engineering: Principles and Applications, Government Institutes*, 2009.
3. A. Gupta, *Industrial Safety and Environment*, (1e), Laxmi Publications Pvt. Ltd., 2006.
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ME3087: PRINCIPLES OF INDUSTRIAL ENGINEERING [3 0 0 3]

Introduction to Industrial engineering: Method study, THERBLIGS, Work measurement methods, Productivity, Ergonomics, Job evaluation: Methods & Incentives, Break Even Analysis, Facility location factors and evaluation of alternate locations, Types of plant layout and their evaluation, Computer aided layout design techniques, Assembly line balancing, Materials handling systems.

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