

(Syllabus i.e. applicable for batch 2017 onwards)

Third Semester

EO 1323

ECONOMICS

[3 0 0 3]

Definition, nature and scope of Economics. Introduction to Micro and Macro Economics. Law of demand and supply, Elasticity of demand and supply. Cardinal and ordinal approaches of Utility. Production: Laws of production, Cost and revenue analysis various market situations, Break-even analysis, Capital Budgeting Macro Economics: National Income and its Concepts, Value of money and its Changes, Foreign Exchange Rate, Monetary and fiscal Policies and other Macro concepts (Balance of Payment, Business Cycle etc.)

Text Book:

1. H.C. Peterson, *Managerial Economics*, Pearson Publication, 9th Edition, 2012.

Reference Books:

1. P.L. Mehta, *Managerial Economics*, Sultan Chand & Sons.
2. G. J. Tiesen and H. G. Tiesen, *Engineering Economics*, PHI.

MA 1313

ENGINEERING MATHEMATICS-III

[3 0 0 3]

Vector Calculus: Gradient, divergence and curl, vector integrals and related theorems. Laplace Transforms: Transforms of elementary functions, inverse transforms, convolution theorem. Application of Laplace in solution of ordinary differential equations with constant coefficients. Fourier series: Fourier series, Dirichlet's conditions, even and odd functions, half range series, change of interval, harmonic analysis. Fourier Transforms: Fourier integrals, complex Fourier transform, Fourier sine and cosine transforms, solution of heat and wave equations. Finite Differences and Interpolation: Finite difference operators, Newton's forward and backward interpolation formula, Lagrange's and Stirling interpolation formula. Numerical differentiation and integration.

Text Books:

1. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, Delhi, 2006.
2. S. Pal, S.C. Bhunia, *Engineering Mathematics*, Oxford University Press, 2015.
3. H.K. Das, *Advanced Engineering Mathematics*, S. Chand, 2015.

Reference Books:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Eastern, 2006.
2. B.V. Ramana, *Higher Engineering Mathematics*, Tata McGraw Hill Education Private Limited, 2007.

ME 1301

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: Miller bravais 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, Schmid's law, strengthening mechanisms: solid solution strengthening, Work hardening; recovery recrystallization and 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, Isomorphous systems eutectic system eutectoid peritectoid reactions, Iron- Carbon equilibrium diagram, Development of microstructure in Iron Carbon alloys, Phase transformation in steel Steel: low, medium, high carbon steels, Stainless steels-ferritic, austenitic, martensitic, duplex steels-tool steels. Cast iron: gray, white, ductile cast irons, Non-Ferrous alloys: Copper and its alloys, Aluminium and its alloys, Magnesium and alloys. Titanium and its alloys.

Text Book:

1. W.D. Callister, *Material Science and Engineering*, Wiley India Pvt. Ltd. 2nd Edition, 2014

Reference Books:

1. V. Raghavan, *Material Science and Engineering*, Prentice Hall of India, 6th Edition, 2015
2. G.K. Narula and K.S Narula, V.K. Gupta, *Material Science*, Tata McGraw Hill, 1st Edition, 2004.

ME 1302

KINEMATICS OF MACHINES

[3 1 0 4]

Mechanism and Machine: Constrained motion, rigid and resistant bodies, link, kinematic pair and degrees of freedom. kinematic chain: Linkage mechanism and structure, mobility and range of movement - Kutzbach and Grubler's criterion, number synthesis, Grashof's criterion, Four bar chain and slider crank chain and its inversions. Introduction to synthesis of mechanism: Transmission angle, definition and determination of maximum and minimum transmission angle, two and three position synthesis of four bar mechanism and slider crank mechanism using graphical method. Displacement, velocity and acceleration analysis of plane mechanisms: Graphical and analytical methods, plane motion of a rigid body, Instantaneous Centre (IC) of velocity, velocity analysis using IC, velocity and acceleration diagrams, Coriolis's component of acceleration. Cam: Types, followers, definitions, displacement, derivatives, design of cam profiles, lay out and different types of contours of cams. Gear: Law of gearing, Spur Gears: definitions, cycloidal and involute teeth, rack and pinion, path of contact, arc of contact, minimum number of teeth, methods of avoiding interference, terminology of helical and bevel gears. Gear Trains: Simple, compound, reverted, epicyclic gear trains, problems to be solved by tabular method, torque calculations, automobile differential gear mechanism. Clutch and Brake: Uniform pressure and wear theory, different types of clutches, different types of brakes, band and block brake, types of dynamometer.

Text Books:

1. S. S. Rattan, *Theory of machines*, Tata McGraw Hill, 4th Edition, 2014.
2. A. Ghosh & A.K. Mallik, *Theory of Mechanisms and Machines*, East West Press, 3rd Edition, 2006

Reference Books:

1. H.H. Mabie and Charles, *Mechanisms and dynamics of machinery*, John Wiley and sons, 4th Edition 1987.
2. J.E. Shigley and J.Uicker, *Theory of Machines and Mechanisms*, Oxford University press, 4th Edition, 2011.
3. R.L. Norton, *Kinematics and Dynamics of Machinery*, Tata McGraw-Hill Education, 1st Edition in SI unit, 2009.

ME 1303**APPLIED THERMODYNAMICS****[3 1 0 4]**

Property relationships for pure substances and Mixtures. Thermodynamic Relations: Some mathematical theorems, Maxwell's equations, TdS equations, Difference in heat capacities, ratio of heat capacities, energy equation, Joule- Thomson effect. Clausius- Clapeyron equation, Evaluation of thermodynamic properties from an equation of state. Helmholtz and Gibbs functions; Enthalpy, entropy, internal energy, and specific heat relations; Clausius-Clapeyron's equation; Applications to ideal and real gases. Joule-Thomson coefficient. Refrigeration Cycle: Basic concepts of refrigeration cycle, Vapour compression refrigeration cycle: components, performance and capacity of the plant, Effect of change in operating conditions on performance of vapour compression cycle, Refrigerant: Designation of chemical formula, selection of refrigerant, chemical properties, physical properties. Reciprocating Compressors: Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of clearance and volumetric efficiency. Adiabatic, isothermal and mechanical efficiencies. Multi-stage compressor, saving in work, optimum intermediate pressure, inter-cooling, minimum work for compression. Compressible Flows and Steam Nozzles: Compressible Flows: Velocity of pressure pulse in a fluid, stagnation properties, one dimensional steady isentropic flow, critical properties-choking in isentropic flow, normal shocks, adiabatic flow with friction and without friction, numerical problems. Steam nozzles: Flow of steam through nozzles, shape of nozzles, effect of friction, critical pressure ratio, supersaturated flow. Psychrometry: Atmospheric air and Psychrometric properties; Dry bulb temperature, wet bulb temperature, dew point temperature; partial pressures, specific and relative humidity and the relation between the two. Enthalpy and adiabatic saturation temperature. Construction and use of psychrometric chart. Analysis of various processes; heating, cooling, dehumidifying and humidifying. Adiabatic mixing of stream of moist air. Summer and winter air-conditioning.

Text Books:

1. P.K. Nag, *Basic and Applied Thermodynamics*, Tata McGraw Hills, 8th Edition, 2006.
2. Estop and McConkey, *Applied Thermodynamics for Engineering Technologies*, Longman, 5th Edition, 2002.

Reference Books:

1. Y.A. Cengel and M.A. Boles, *Thermodynamics: an Engineering Approach*, McGraw Hill, 5th Edition, 2005.
2. C. Borgankke and R.E. Sontag, *Fundamental of Thermodynamics*, Wiley, 8th Edition, 2009.

ME 1304**STRENGTH OF MATERIALS****[3 0 0 3]**

Introduction: Rigid and Deformable bodies, Strength, Stiffness and Stability, Stresses, Tensile, Compressive and Shear, Elastic constants, Strain energy and unit strain energy, Strain energy in uniaxial loads. Beams-Loads and Stresses: Types of beams, Supports and Loads, Shear force and Bending Moment in beams, Cantilever, Simply supported and Overhanging beams, Stresses in beams, Theory of simple bending, Stress variation along the length and in the beam section, Effect of shape of beam section on stress induced, Shear stresses in beams, Shear flow. Torsion: Analysis of torsion of circular bars, Shear stress distribution, Bars of Solid and hollow circular section, Stepped shaft, Twist and torsion stiffness, Fixed and simply supported shafts. Beam deflection: Elastic curve of Neutral axis of the beam under normal loads, Evaluation of beam deflection and slope, Columns, End condition, Equivalent length of a column, Euler equation, Slenderness ratio, Rankine formula for columns; Analysis of stresses in two

dimensions: Biaxial state of stresses, Thick & Thin cylindrical shells and spherical shells, Deformation in thick and spherical shells, Biaxial stresses at a point, Stresses on inclined plane, Principal planes and stresses, Mohr's circle for biaxial stresses, Maximum shear stress.

Text Books:

1. Pytel and Singer, *Strength of Materials*, Harper & Collins, 4th Edition, 2011.
2. Timoshenko, *Strength of Materials*, vol. 1, CBS publications, 3rd Edition, 2014

Reference Books:

1. Beer & Johnston, *Vector Mechanics for Engineers*, Tata McGraw Hill, 9th Edition, 2010
2. F.L. Singer, *Engineering Mechanics*, Harper & Row, 3rd Edition, 1994
3. E.P Popov, *Mechanics of Materials*, S.I. Version, PHI, 2nd Edition, 1998.
4. S. Ramamrutham, *Strength of Materials*, Dhanpat Rai Publication, 18th Edition, 2014

ME 1331

COMPUTER AIDED MACHINE DRAWING LAB

[0 0 4 2]

Introduction to design process and drawings of CREO 2.0. 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.

Text Books:

1. K.L. Narayana, *Machine Drawing*, Wiley Eastern , 2nd Edition, 2009.
2. CREO 2.0 online web Tutorials.

ME 1332

STRENGTH OF MATERIALS LAB

[0 0 2 1]

Izod Impact testing; Rockwell Hardness Testing; Spring Testing; Column Testing for buckling; Vicker's Hardness Test; Torsion Testing; Tensile Testing; Compression Testing; Shear Testing; Brinell Hardness Testing; Bending Test on UTM; Study of Fatigue Testing Machine.

Text Book:

1. R. Subramanian, *Strength of Material*, Oxford Univ. Press, 2nd Edition, 2010.
2. A.V.K Suryanarayan, "Testing of Materials" PHI, 2nd Edition, 1990.

Reference Book:

1. Technical Teachers, Training Institute, Lab Manual of Strength of Materials, oxford Univ. press, 1983.

Forth Semester

MA 1410

ENGINEERING MATHEMATICS-IV

[3 0 0 3]

Tensor: Introduction to tensors, Cartesian tensors, Rank of tensor, First, second and higher order tensors, Algebraic operation on tensors, contraction of tensors, Contravariant and covariant vectors and tensors, Theorems based on tensors. Solution of Non-Linear Equations: Bisection, Newton-Raphson, Regula Falsi, Secant methods. System of Simultaneous Linear Equations: Gauss elimination method, Gauss-Jacobi, Gauss-Seidel. Solution of Initial Value Problems: Taylor's series method, Euler method, modified Euler method, Runge-Kutta 4th order method. Finite Difference Methods: Solution of Laplace and Poisson equations by standard five point formula, solution of heat equations by Crank-Nicolson method, solution of wave equations. Statistics: Correlation, Regression, random variables, probability distributions- Binomial, Poisson and Normal.

Text Books:

1. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, Delhi, 2006.
2. S. Pal, S.C. Bhunia, *Engineering Mathematics*, Oxford University Press, 2015.
3. H.K. Das, *Advanced Engineering Mathematics*, S. Chand, 2015.

Reference Books:

1. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley India Eastern, 2006.
2. B.V. Ramana, *Higher Engineering Mathematics*, Tata McGraw Hill Education Publication Limited, New Delhi, 2007.

ME 1401

FLUID MECHANICS & HYDRAULIC MACHINES

[3 1 0 4]

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, vorticity, circulation, Stream function, Velocity Potential function, Cauchy Riemann equation. Fluid Dynamics: Euler's and Bernoulli's equation, Bernoulli's theorem, Applications of Bernoulli's equation, Vortex Motion: Free and Forced. Viscous flow: Reynold's Number, Darcy Weisbach equation, Laminar flow: circular pipe (Hagen Poiseuille's equation), Parallel Plates; Flow: Pipe flow, Friction factor, Minor and major losses in pipe, Boundary layer concept, Boundary layer separation. Dimensional Analysis: Basic and derived quantities, similitude and dimensional analysis, Buckingham π -theorem, non-dimensional parameters and its significance. Hydraulic Machines: Rotating Elements: - Classification and efficiencies of turbines, performance curve. Reciprocating Pump: - Working principle, discharge, work done, efficiency, slip. Centrifugal Pump: - Working principle, indicator diagram, components, Efficiency, Pump characteristics, multistage centrifugal pump.

Text Books:

1. F.M. White, *Fluid Mechanics*, Tata McGraw Hills Pub., 7th Edition, 2011.
2. P.N. Modi and Seth, *Fluid Mechanics*, Standard Book House Pub., 18th Edition, 2011.

Reference Books:

1. Y.A. Cengel, J.M. Cimbala, *Fluid Mechanics*, McGraw-Hill Higher Education, 3rd Edition, 2014.
2. A. K. Jain, *Fluid Mechanics Including Hydraulic Machines*, Khanna Publication, 12th Edition, 2010.

3. R. K. Bansal, *Fluid Mechanics and Hydraulic Machines*, Laxmi Publications, 9th Edition, 2015.

ME 1402

DYNAMICS OF MACHINES

[3 0 0 3]

Static forces in Machines: Conditions of static equilibrium of a member under action of two forces, three forces, four forces and forces and a couple, Analysis of slider crank mechanism and four bar mechanism, example of quick return mechanism, virtual work. Dynamic force analysis: Inertia forces, D'Alemberts Principle, Inertia forces of connecting rod, inertia forces in slider crank mechanism, four bar mechanism, dynamically equivalent system, forces in engines. Flywheel: Turning moment diagram of single cylinder engines, multi cylinder engines, mass and size of flywheel. Governors: Centrifugal governors such as Porter, Proell, Hartnell, and Wilson Hartnell. Characteristics of governors, stability, Sensitiveness, isochronism, hunting, controlling force, effort and power of governors. Balancing: Balancing of rotating masses in machinery, Balancing in same plane, balancing in different planes, balancing of reciprocating masses, Primary balancing and Secondary balancing of multi cylinder engines, inline engines, V-engines, and radial engines using direct and revers cranks concept.

Gyroscope: Principle of Gyroscopic couple, Effect of gyroscopic couple and centrifugal force on vehicle taking a turn, Stabilization of sea vessels, Condition for stability of a four wheeler and two wheeler.

Text Books:

1. S. S. Rattan, *Theory of machines*, Tata McGraw Hill, 4th Edition, 2014.
2. A. Ghosh & A.K. Mallik, *Theory of Mechanisms and Machines*, East West Press, 3rd Edition, 2006

Reference Books:

1. H.H. Mabie and Charles, *Mechanisms and dynamics of machinery*, John Wiley and sons, 4th Edition, 1987.
2. J.E. Shigley and Jr.Uicker, *Theory of Machines and Mechanisms*, Oxford University press, 4th Edition, 2011.
3. R.L. Norton, *Kinematics and Dynamics of Machinery*, Tata McGraw-Hill Education, 1st Edition in SI unit, 2009.

ME 1403

PRODUCTION TECHNOLOGY-I

[3 1 0 4]

Casting: Introduction to casting, Patterns, types, materials, Allowances, Moulding sand composition, types of mould, Sand Testing Machine, Core types, Core making sands, Chills & Chaplets, Forces acting on Moulding flasks, Introduction to Crucible Melting & Cupola operation, Principles and design of Gating system, Gating Ratio, Riser types & Design, Concept of Solidification of casting, Introduction to Sand Casting, Special Casting Process Shell Mould Casting, Investment Casting, Die casting, Centrifugal Casting, CO₂ Moulding, Applications-Advantages-Disadvantages of above processes, Defects in casting, causes & remedies. Metal Joining: Principles of welding, soldering, brazing. Types of welds and welded joints, Arc Welding its types Working, power sources, and electrodes and their coatings, weld bead geometry, V-I characteristic curves of power source, Simple Problems of V-I characteristic, Shielded Metal Arc Welding, Submerged Arc Welding, Gas Tungsten Arc Welding, Gas Metal Arc Welding, Gas Welding and Gas Cutting, Applications-Advantages-Disadvantages of above processes, Resistance Welding, Seam Welding, Projection Welding, Spot Welding, Heat Affected Zone in Welding,

Minimization of HAZ, Special Welding Process – Friction Welding, Thermit Welding. Defects in Welding, causes & remedies. 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 Moulding)

Text Books:

1. S. Kalpakjian and S.R. Schmid, *Manufacturing Engineering and Technology*, Pearson Education, 6th Edition, 2009.
2. A. Ghosh, and A.K. Malik, *Manufacturing Science*, Affiliated East West Press Pvt. Ltd., 2nd Edition, 2010.

Reference Books:

1. P.C. Sharma, *A text book of Production Technology*, S. Chand and Company, 4th Edition, 2006.
2. R.K. Jain, *Production Technology: Manufacturing Processes, Technology and Automation*, Khanna Publishers, 17th Edition, 2011.
3. P.N. Rao, *Manufacturing Technology Volume-1*, Tata McGraw-Hill Education, 4th Edition, 2013.

BB1101

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.

Text Books:

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

ME 1431

PRODUCTION TECHNOLOGY I LAB

[0 0 2 1]

Introduction: smithy and foundry; Practical study on smithy process: preparation of models; Practical study on moulding process: by preparation of models; Practical study on non-ferrous: metal casting. Welding Practice: Preparation of welding joints by gas welding and arc welding.

Text Books:

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

ME 1432 FLUID MECHANICS & HYDRAULIC MACHINES LAB [0 0 2 1]

Flow measuring devices: Calibration of rectangular and V notch, orifice, orifices meter and venturimeter; Friction in pipe: Determination of friction factor for the given pipe with water has fluid and Reynold's number; Impact of jet on Vanes: Curved vanes and flat inclined vane; Characteristic and performance testing of various types of turbines and pumps: Pelton wheel, Francis turbine, single stage centrifugal pump; Characteristic and performance testing of pumps: Gear pump, reciprocating pump, two stage centrifugal pump; Performance testing: Hydraulic ram. Bernoulli's theorem and its Verification

Text Books:

1. K. L. Kumar, *Fluid Mechanics*, Eurasia, 2000.
2. Cengel and Cimbala, *Fluid Mechanics*, McGraw Hills, 2001

Reference Book:

1. S. Ramarutham, *Hydraulic Fluid Mechanics and Fluid Machines*, Dhanpat Rai Publication, 1999.

Fifth Semester

ME1506 Design of Machine Elements-I [3 1 0 4]

Machine Design philosophy. Engineering Materials: Stress-strain diagrams for ductile and brittle materials, Stresses in Machine Elements: Types of simple stresses, State of stress at point-implications,

principal stresses and compound stresses. Design for strength: Static loading, Theories of failures, Allowable stress, Factor of safety, Stress concentration factor, curved beams. Variable and impact loading. Shafts - ASME & ISI code equations for design of transmission shafts, design of shafts subjected to combined load. Key and couplings design. Riveted joints: Structural joints of lap & butt types, Boiler joints, Rivets Coursed to eccentric loading conditions. Welded joints: Types of welding joints and symbols, Strength of welded joints and Design principle. Eccentric loading in welded joint Threaded fasteners, Power screws.

Text Book:

1. J.E. Shigley and C.R. Mischke, *Mechanical Engineering Design*, McGraw Hill Publication, 7th Edition, 2003.

Reference Books:

1. R. L. Norton, *Machine Design-An Integrated Approach*, Pearson Publisher, 5th Edition, 2013.
2. U.C. Jindal, *Machine Design*, Pearson publisher, 1st Edition, 2010.
3. V. B. Bhandari, *Machine Design Data book*, McGraw Hill Publication, 2014.

ME1507

Heat & Mass Transfer

[3 1 0 4]

Introduction, Various modes of heat transfer. Conduction, Fourier law of heat conduction, Heat diffusion equation in Cartesian, Cylindrical and Spherical coordinate system, One dimensional steady state conduction applied to various cases e. g. plane wall, cylinder, sphere etc. Heat transfer from extended surfaces, Critical radius of insulation for cylinder & sphere, overall heat transfer coefficient, Convection, Review of Concept to Boundary Layer, empirical correlation for free & forced convection. Concept of Boiling and Evaporation, Boiling modes, Condensation: physical mechanism, Film and Dropwise condensation. Heat Exchanger, Heat Exchanger Analysis by LMTD and Effectiveness-NTU method. Radiation: - Radiation Intensity, Absorption, Reflection and Transmission by real surfaces, Kirchhoff's Law, Gray surface. Radiation exchange between surfaces, Gray surfaces in an enclosure. Mass transfer: Introduction, diffusion mass transfer, Fick's law of diffusion, steady state molecular diffusion.

Text Book:

1. J.P. Holman, *Heat Transfer*, McGraw Hill Publication, 10th Edition, 2009

Reference Books:

1. P. F. Incropera, D. P. Dewitt, *Fundamentals of Heat and Mass Transfer*, John Wiley Publication, 7th Edition, 2014.
2. A. Yunus, Cengel, *Heat Transfer-A practical Approach*, McGraw Hill Publication, 4th Edition, 2011.
3. P.K. Nag, *Heat & mass transfer*, McGraw Hill Publication, 3rd Edition, 2011.

ME1508

Production Technology-II

[4 0 0 4]

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.

Text Books:

1. A. Ghosh, and A.K. Malik, *Manufacturing Science*, Affiliated East West Press Pvt. Ltd., 2nd Edition, 2010.
2. P.N. Rao, *Manufacturing Technology Volume-2*, McGraw Hill Publication, 4th Edition, 2013.
3. S. Kalpajian, and S.R. Schmid, *Manufacturing Engineering and Technology*, Pearson Publication, 4th Edition, 2002.

Reference Books:

1. P.C. Sharma, *A text book of production technology*, S. Chand Publication, 4th Edition, 2003.
2. R.K. Jain, *Production technology: Manufacturing Processes, Technology and Automation*, Khanna Publication, 17th Edition, 2011.

ME1533

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, 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.

Text Book:

1. S.K.H. Choudhary and A.K.H. Choudhary, *Elements of Workshop Technology Vol. 2*, Media Promoters & Publications Pvt Ltd., 2010.

Reference Book:

1. B.S. Raghuvanshi, *A course in Workshop Technology Vol. 2*, Dhanpat Rai, 2015.

ME1534

Heat & Mass Transfer Lab

[0 0 2 1]

Determination of calorific values of gaseous fuels by Boys calorimeter; Determination of flash and fire points of oils (Open Cup); Determination of flash and fire points of oils (close Cup). 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.

Reference Book:

1. M. Thirumaleshwar, *Fundamentals of Heat and Mass Transfer*, Pearson Publication, 1st Edition, 2006.

Sixth Semester

ME1605

Design of Machine Elements -II

[3 1 0 4]

Spring design: introduction and spring materials. Design of Helical springs for static and fluctuating loads, buckling of compression springs. Gear design: introduction, Gear manufacturing and Gear materials, load analysis on gear tooth, Calculation of Virtual number of teeth and Contact Ratio, Stresses on gears. Lubrication of Gearings. Bearing and Lubrication: Introduction of Bearings, Bearing load life at rated reliability and section of Antifriction Bearings. Lubrication for Antifriction Bearing, mounting and enclosures. Journal Bearing: Types of journal bearings and lubrications, Material combination in Journal bearings, Hydrodynamic lubrication theory, Design of Hydrodynamic bearings and Non-conforming Contacts. Design of Flexible Mechanical elements: Introduction, design of flat belt and V- belt, design of flywheel wire rope design. Design of chain drives.

Text Book:

1. J.E. Shigley and C.R. Mischke, *Mechanical Engineering Design*, McGraw Hill Publication, 7th Edition, 2003.

Reference Books:

1. R. L. Norton, *Machine Design-An Integrated Approach*, Pearson Publication, 5th Edition, 2013.
2. U.C. Jindal, *Machine Design*, Pearson Publication, 1st Edition, 2010.
3. V. B. Bhandari, *Machine Design Data book*, McGraw Hill Publication, 2014.

ME1606

Internal Combustion Engine

[3 1 0 4]

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.

Text Books:

1. J. B. Heywood, *Introduction to Internal Combustion Engines*, McGraw Hill Publication, 2011.
2. V. Ganeshan, *Internal Combustion Engine*, McGraw Hill Publication, 4th Edition, 2012.

Reference Books:

1. C. Ferguson, *Internal Combustion Engines*, John Wiley & Sons, 2nd Edition, 2016.
2. R. Stone, *Introduction to Internal Combustion Engines*, The McMillan Press, 4th Edition, 2012.

ME1607**Metrology****[3 0 0 3]**

Measurements & Measurement Systems: Measuring Standards. Static Characteristics of Instruments & measurement systems, Measurement of Pressure, Temperature, strain, force, torque and Shaft work. Limits, Fits and Tolerances: Interference and Transition fits, System of fits, Hole basis and Shaft basis. Gauges: Types of gauges & design. Measurement of Form Errors: Flatness, straightness and squareness measurement, Engineer's Square tester, Optical Square. Comparators, Principles, construction & working of mechanical & optical comparators. Screw Threads: Design principle and application. Surface Texture measurement: Methods of 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.

Text Book:

1. A.K. Bewoor & V. Kulkarni, *Metrology & Measurement*, McGraw Hill Publication, 2012.

Reference Book:

1. N.V. Raghavendra & L. Krishnamurty, *Engineering Metrology & Measurements*, Oxford Publications, 2013.

ME1633**Internal Combustion Engine Lab****[0 0 2 1]**

Cut Sectional 4 Stroke 1 Cylinder Petrol Engine for valve timing diagram; 4 stroke 4 cylinder Diesel engine test rig with Electrical dynamometer; Evaluating friction by morse test on multi cylinder 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; To Determination The Compression Ratio of Computerised CI Engine; Performance test of two stroke SI Engine (Single cylinder) with AC generator; Performance test of four stroke single cylinder CI engines test rig with DC generator; Performance test of four stroke single cylinder CI engines test rig with rope brake dynamometer; Performance test of four stroke single cylinder CI engines test rig with hydraulic dynamometer

Text Book:

1. S. Domukundwar, C.P. Kothandaraman, *A course in Thermal Engineering*, Dhanpath Rai, 2002.

Reference Book:

1. P.L. Ballaney, *Internal Combustion Engines*, Khanna Publication, 2007.

ME1634**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; Radius measurement; Angle measurement; Demonstration of surface texture measurement; Demonstration of use of Coordinate Measuring Machine; Straightness measurement; Measurement using Interferometer; Acceptance test on Lathe; Acceptance test on Drilling machine; Acceptance test on Milling machine; Acceptance test on

Shaper; Measurement of Tool tip temperature; Use of Dynamometers for Machine Tool applications; Use of Planimeter; Pressure Gauge Calibration, indirect measurement techniques.

Text Book:

1. A.K. Bewoor & V. Kulkarni, *Metrology & Measurement*, McGraw Hill Publication, 2012.

Reference Book:

1. N.V. Raghavendra & L. Krishnamurty, *Engineering Metrology & Measurements*, Oxford Publication, 2013.

Seventh Semester

ME1706 Refrigeration and Air Conditioning [3 0 0 3]

Introduction to basic refrigeration cycles: Reverse carnot cycle, Effect of temperatures, Air refrigeration cycles, Bell- Coleman cycle, Air refrigeration cycles for aircrafts, Ideal & Actual vapour compression cycle: Compound vapour compression refrigeration system, Multi evaporator and cascade systems, Ammonia absorption refrigeration, Lithium Bromide absorption system, Absorption versus compression refrigeration systems, Refrigerants by class, CFC, HFC and HCFC refrigerant blends, Comparison of thermodynamic properties of refrigerants, Steam jet refrigeration, Air Conditioning: Psychometric properties and charts, Psychrometric of air conditioning process, Summer and winter air conditioning, Calculation of heating and cooling loads, Design of air conditioning systems.

Text Books:

1. S.C. Arora and S. Domkundwar, *A Course in Refrigeration and Air-conditioning*, Dhanpat Rai, 1997.
2. N. Cook, *Refrigeration and Air conditioning*, Macmillan Education, 1995.
3. W.F. Stocker, *Refrigeration and Air conditioning*, McGraw Hill Education, 1985.

Reference Book:

1. M. Prasad, *Refrigeration and Air conditioning*, New Age International, 2007.

ME1707 Mechanical Vibration [4 0 0 4]

Introduction to vibration, Longitudinal, Lateral and torsional vibration systems, Single degree of freedom, Free and forced Vibration: Equation of motion, Viscous and Coulomb damped vibration, whirling of shaft. Harmonic forced vibration, Rotary and reciprocating unbalance, Vibration isolation, Periodic and impulse vibration, Two degrees of freedom systems, Equation of motion using classical methods, Modal analysis using Eigen method, Vibration absorber. Multi degree freedom systems, Flexibility and stiffness matrices, Iterative methods: Holzer method, Matrix iteration, Rayleigh and Dunkerley's methods for modal analysis. Torsional vibration: Multi Degree of Freedom system, Geared system. Introduction to continuous systems.

Text Books:

1. S.S. Rao, *Mechanical Vibration*, Pearson Education, 4th Edition, 2004.
2. G.K. Grover, *Mechanical Vibrations*, Nem chand & Bros, 8th Edition, 2009.
3. J.D. Imnan, *Engineering Vibration*, Pearson Education, 4th Edition 2013.

Reference Books:

1. W.T. Thomson, *Theory of Vibrations with Applications*, Chapman and Hall, 4th Edition, 1993.
2. V.D. Rao, *Text Book of Mechanical Vibration*, Prentice Hall of India Ltd., 2nd Edition, 2012.

ME1708 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].

Text Books:

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*, Pearson International Edition, 3rd Edition, 2008.

Reference Books:

1. K. Yoram, Ben and U. Joseph, *Numerical Control of Machine Tools*, Khanna Publishers, 2005.
2. P. Radhakrishnan, *Computer Numerical Control Machines*, New Academic Science Ltd., 2nd Edition, 2014.

ME1709**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.

Text Books:

1. I.K. Zeid, *CAD/CAM Theory and Practice*, McGraw Hill Education, 2nd Edition, 2009.
2. D.F. Rogers and J.A. Adams, *Mathematical Elements for Computer Graphics*, McGraw Hill Education, 2nd Edition, 2002.

Reference Book:

1. D.F. Rogers and J.A. Adams, *Procedural Elements for Computer Graphics*, McGraw Hill Education, 2nd Edition, 1998.

ME1732**Mechanical Vibration Lab****[0 0 2 1]**

Simple and compound pendulum, Bifilar suspension, Undamped longitudinal free vibration of a spring, Torsional undamped and damped free vibration, Damped Forced vibration, Transverse vibration of beam and Whirling of shaft, Static and dynamic balancing of rotary masses.

Text Books:

1. S.S. Rao, *Mechanical Vibration*, Pearson Education, 4th Edition, 2004.
2. G.K. Grover, *Mechanical Vibrations*, Nem chand & Bros, 8th Edition, 2009.
3. J.D. Imnan, *Engineering Vibration*, Pearson Education, 4th Edition 2013.

Reference Books:

1. W.T. Thomson, *Theory of Vibrations with Applications*, Chapman and Hall, 4th Edition, 1993.
2. V.D. Rao, *Text Book of Mechanical Vibration*, Prentice Hall of India Ltd., 2nd Edition, 2012.

ME1733**Refrigeration and Air Conditioning Lab****[0 0 2 1]**

Study of basic components, Determine the COP and tonnage capacity of VCR test rig, Discuss the types of modified VCR cycles with T-s and P-h diagram. 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. Study of basic components to 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.

Text Book:

1. S.C. Arora and S. Domkundwar, *A Course in Refrigeration and Air-conditioning*, Dhanpat Rai, 1997.

ME1734

Computer Aided Design Lab

[0 0 2 1]

Introduction to design process and modeling using CATIA, Sketcher, Part design, Dimensioning and notes. Assembly drawings with sectioning and bill of materials. Finite Element Analysis using ANSYS 2D spur 2D beam element, 2D solid element, 2D thermal element, Shell element, 3D solid element. CNC turning, CNC milling.

Text Book:

1. S. Tickoo, *CATIA V5-6R2016 for Designers*, BPB Publications, 14th Edition 2017.

Program Elective:

ME1553

Industrial Engineering

[3 0 0 3]

Definition of Industrial Engineering: Objectives, 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. Relevant costs, Costs of quality, Statistical quality Control (SQC), Variables & Attributes, Production Planning & Control (PPC) : Introduction to Forecasting - Simple & Weighted moving average methods, Aggregate planning, Master production schedule (MPS), Sequencing - Johnson algorithm for n-Jobs-2 machines, n- Jobs-3 machines, n-Jobs m-machines.

Text Books:

1. S.N. Chary, *Production & Operations Management*, McGraw Hill Publication, 4th Edition, 2009.
2. E. E. Adam, R. J. Ebert, *Production and Operation Management: Concepts, Models, and Behaviour*, Prentice Hall Publishers, 5th Edition, 1992

Reference Books:

1. S.S. Buffa, *Modern Production Management*, John Wiley Publication, 8th Edition, 2007.
2. P. Kumar, *Industrial Engineering and Management*, Pearson Publication, New Delhi, 1st Edition, 2015.

ME1554

Finite Elements Methods

[3 0 0 3]

Matrix Algebra, Theory of Elasticity: Equilibrium equations, Stress-Strain relations, Compatibility equations, Plane stress and plane strain equations. Fundamentals of FEM, Direct Stiffness Approach (e.g. spring system), One Dimensional Elements: Bars- uniform, varying and Trusses. Beams, Plane frame. Stiffness matrix, force and Displacement vectors, and Governing differential equations for such problems, Minimization of functional as solution of governing equations: Variational approach, Potential energy approach, Rayleigh Ritz methods, weak formulations and weighted residual (Galerkin method) methods, Boundary value problems: Rayleigh Ritz and Galerkin approach.

Text Books:

1. J. N. Reddy, *An Introduction to the Finite Element Method*, McGraw Hill Publication, 3rd Edition, 2006.
2. K. J. Bathe, *Finite Element Procedures*, Prentice Hall Publishers, 2nd Edition, 2007.

Reference Books:

1. T. R. Chandrupatla and A. D. Belegundu, *Introduction to Finite Elements in Engineering*, Pearson Publication, 4th Edition, 2015.
2. R.D. Cook, D.S. Malkus, M.E. Plesha and R.J. Witt, *Concepts and Applications of Finite Element Analysis*, John Wiley Publication, 4th Edition, 2007.

ME1555**Turbomachinery****[3 0 0 3]**

Basic Concepts of Turbo Machines: Basic laws and governing equations, continuity equation, steady flow energy equation, Newton's 2nd law of motion applied to turbomachines - Euler's pump equation and Euler's turbine equation, dimensional analysis applied to hydraulic machines, power coefficient, flow coefficient, head coefficient, non-dimensional specific speed, Dimensional analysis applied to compressible flow machines. Centrifugal Turbine and Fans: Velocity diagrams, slip factor, energy transfer, power input factor, stage pressure rise and loading coefficient, pressure coefficient, degree of reaction, Centrifugal compressor characteristic, surging, rotating Stall and Choking. Axial Flow Turbine and Fans, turbine versus compressor blades, Axial flow compressors, working principle, velocity triangle, stage work, work done factor, stage loading, degree of reaction; vortex theory, Introduction to blade design, cascade test, compressibility effects, operating characteristics.

Text Books:

1. A.T. Sayers, *Hydraulic & Compressible flow Turbomachines*, McGraw Hill Publication, 1990.
2. S.L. Dixon, *Fluid Mechanics, Thermodynamics of Turbomachinery*, Pergamon, 2006.

Reference Books:

1. S.M. Yahya, *Turbomachines*, Satya Prakashana, New Delhi, 2005.
2. S.M. Yahya, *Turbines Compressors and Flans*, McGraw Hill Publication, 2005.

ME1556**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. Glass, carbon and advanced fiber manufacturing methods, applications, advantages, disadvantages and properties; Micro mechanical analysis of a lamina: Derivation of stress, strain, Modulus of elasticity of fiber reinforced composites. Rule of mixture, mechanical properties of composites by using Rule of mixture; Manufacturing of polymer composites: description of method, advantages, disadvantages and application. Open and closed mold processing, Hand-lay-up technique, Spray up process, Bag molding, Filament winding, Pultrusion, Thermoforming, Injection molding, Resin Transfer molding, Sheet molding Compound, Dough molding Compound, Thick molding Compound, Machining and joining, Tooling, Quality assurance, Material qualification.

Text Books:

1. M. Schwartz, *Composite Materials handbook*, McGraw Hill Publication, 2nd Edition, 1992.
2. A.K. Kaw, *Mechanics of composite materials*, Taylor & Francis-India, 2nd Edition, 2010.

Reference Book:

1. K.K. Chawla, *Composite material science and Engineering*, Springer, 3rd Edition, 2012.

ME1653**Optimization Techniques****[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: Initial basic

feasible solution algorithms, MODI, stepping stone method. Assignment Method: Hungarian, travelling salesman problems. Job sequencing method. Network Models: Critical Path Method, Project Evaluation and Review Technique (PERT). Non-linear Programming: One-dimensional minimization: Unimodal function, unrestricted search, Golden section method. Non-linear Programming: Unconstrained Optimization Techniques: Direct Search Methods: Random search methods, Grid search method, Univariate method, Modern Methods of Optimization.

Text Books:

1. S.S. Rao, *Engineering Optimization: Theory and Practice*, New Age International Publishers, 3rd Edition, 2013.
2. H.A Taha, *Operations Research; An Introduction*, Pearson Publication, 9th Edition 2014.
3. K. Deb, *Optimization for Engineering Design Algorithms and Examples*, Prentice Hall Publishers, 2nd Edition, 2012.

Reference Book:

1. J.C Pant, *Introduction to Optimization techniques*, Jain Brothers, 7th Edition, 2008.

ME1654 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 vapor deposition, chemical vapor deposition, Epitaxy, sol-gel method, spin coating, Silicon Morphology and Miller Indices. Photolithography, Etching (Chemical and physical), Deep Reactive Ion Etching, Bulk micromachining, Surface Micromachining, LIGA, Process Modeling and case studies of process models of micro-cantilever, micro hinges, micro pressure sensors, transistors, gates, micro-robots, Microsensors: Pressure sensor, gyroscope, accelerometer etc., Microactuators: Electrostatic micro-comb drives, Piezoelectric, Shape Memory alloys, Metrology, Microfluidics, Bio-Nano: Materials and processes, Biochips, Microarrays and System on Chip.

Text Book:

1. C. Liu, *Foundation of MEMS*, Pearson Publication, 2011.

Reference Books:

1. M. Madou, *Fundamentals of Microfabrication*, CRC Press, 2nd Edition, 2002.
2. S.D. Senturia, *Microsystem Design*, Kluwer Academic Publishers, 2001
3. N. Maluf, *An Introduction to Microelectromechanical Systems Engineering*, Artech House, 2nd Edition, 2004.

ME1655 Tool Engineering [3 0 0 3]

Fundamental of Tool design practice, procedure of tool design, Design of single point cutting tools such as solid tools , tipped tools, coated tipped tools, throw away type tools and diamond tools; Design of milling cutters, gear milling cutters, hobs gear shaping tools, broaches, drills, 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.

Text Book:

1. C. Donaldson, G.H. Lecain, V.C. Goold, *Tool Design*, McGraw Hill Publication, 4th Edition 2013.

Reference Book:

2. A.B. Chattopadhyay, *Machining and Machine Tools*, John Wiley Publication, 2015

ME1656

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.

Text Books:

1. J. B. Heywood, *Introduction to Internal Combustion Engines*, McGraw Hill Publication, 2011.
2. V. Ganeshan, *Internal Combustion Engine*, McGraw Hill Publication, 4th Edition, 2012.

Reference Books:

1. C. Ferguson, *Internal Combustion Engines*, John Wiley Publication, 2nd Edition, 2016.
2. R. Stone, *Introduction to Internal Combustion Engines*, McMillan Press, 4th Edition, 2012.

ME1657

Advanced Manufacturing Techniques

[3 0 0 3]

Rapid Prototyping (RP): Introduction, Characteristics of RP Technologies, Subtractive and Additive Processes, Fused Deposition Modeling, Stereo lithography, laminated object manufacturing and three dimensional printing, applications of RP. **Advanced Casting Processes:** Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting. **Advanced Welding Processes:** Electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW). **Nontraditional Machining:** Electrical discharge machining, Laser Beam Machining, Ultrasonic Machining, Electron beam machining, Abrasive jet machining, Water jet machining, Hybrid and Micro Machining Processes.

Text Books:

1. S. Kalpakjian, *Manufacturing Engineering and Technology*, Addison Wesley Longman, 4th Edition, 2002.
2. A. Ghosh & A.K. Malik, *Manufacturing Science*, Affiliated East West Press Pvt. Ltd., 2nd Edition, 2010.

Reference Book:

1. P.C. Pandey and H.S. Shan, *Modern Machining Processes*, McGraw Hill Publication, 1980.

ME1658**Production and Operations Management****[3 0 0 3]**

Introduction to production and operations management: Objectives, scope and functions of production management, planning, organizing, controlling in 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, types of plans, strategy and aggregate production planning, master production schedule, production control. Plant location and layout: Types of layout, methodology of layout planning.

Text Books:

1. W. J. S. Irwin, *Operation Management*, McGraw Hill Publication, 9th Edition, 2005.
2. S. Paton, B. Clegg, J. Hsuan, and A. Pilkington, *Operations Management*, McGraw Hill Publication, 2011.

Reference Book:

1. K. Aswathappa, S. Bhat, *Production and Operations management*, Himalaya Publication, 2nd Edition, 2015.

ME1659**Heat treatment****[3 0 0 3]**

Heat Treatment Processes: Annealing- its types and effect on mechanical properties, Normalizing, Hardening, Tempering, Surface hardening, Quenching. Chemical heat treatment of steels: Carburising and its types, post carburizing treatments, Cyaniding and Carbonitriding, 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 and application of Non-ferrous metals and alloys.

Text Books:

1. T.V. Rajan, C.P. Sharma and A. Sharma, *Heat treatment principles and techniques*, Prentice Hall Publishers, 2nd Edition, 2010.
2. W. Bolton, *Engineering materials technology*, Heinmann Newness, 3rd Edition, 2001.

Reference Books:

1. B. Zakharov, *Heat treatment of Metals*, Mir Publishers, 1st Edition, 2002.
2. K.E. Thelning, *Steel and its heat treatment*, Oxford Publication, 2nd Edition, 2013.
3. R.C. Sharma, *Principles of Heat Treatment of Steels*, New Age International (P) Limited, 2010.

ME1660**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.

Text Books:

1. H.L. Harrison and J.G. Bollinger, *Automatic controls*, TBS The Book Service Ltd, 2nd Edition, 1969.
2. K. Ogata, *Modern Control Engineering*, Pearson Publication, 5th Edition, 2015.

Reference Books:

1. S.N. Verma, *Automatic Control Systems*, Khanna Publishers, 1990.
2. F.H. Raven, *Automatic Control Engineering*, McGraw Hill Publication, 5th Edition, 2013.

ME1756**Robotics****[3 0 0 3]**

Introduction to Robotics, Control and path movement, End effectors, Sensors, Gripper and actuators, Concept of Robotic/Machine vision, Teach pendent. Coordinate frames, Description of objects in space, Transformation of vectors. Direct kinematic model mechanical structure and notations, Description of links and joints, Kinematic modeling of the manipulator, Denavit Hartenberg notation, Kinematic relationship between adjacent links, Manipulator transformation matrix. Introduction to inverse kinematic model. Robot applications.

Text Books:

1. M.P. Grover, *Industrial Robotics Technology, Programming and Applications*, McGraw Hill Education, 2nd Edition, 2012.
2. S.B. Niku, *Introduction to Robotics: Analysis, Systems, Applications*, Prentice Hall, 2001.

Reference Books:

1. S.R. Deb and S. Deb, *Robotics Technology and Flexible Automation*, McGraw Hill Education, 2nd Edition, 2009.
2. J.J. Craig, *Introduction to Robotics, Mechanics and Control*, Pearson, 3rd Edition, 2004.

ME1757**Power Plant Engineering****[3 0 0 3]**

Steam power plant, Rankine cycle improvisation, Layout, Components and accessories, Steam and heat rate, Coal and ash handling systems, Draught system, Feed water system, Binary cycles and cogeneration systems. Diesel and Gas Turbine Plant: Otto, Diesel, Dual & Brayton Cycle - Analysis & optimization, Components, Combined cycle power plants. Nuclear Power Plants: Location, Component of nuclear plants, Types of reactors, Uranium enrichment, Safety, Disposal of nuclear waste, Comparison with thermal 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, Site selection, Pollution control.

Text Books:

1. S. Domkundwar, *Power plant Engineering*, Dhanpat Rai, 8th Edition, 2016.
2. R.K. Rajput, *Power Plant Engineering*, Laxmi Publications (P) Ltd, 5th Edition, 2016.

Reference Books:

1. P.K. Nag, *Power Plant Engineering*, McGraw Hill Education, 4th Edition, 2017.
2. G.R. Nagpal, *Power Plant Engineering*, Khanna Publishers, 2008.
3. M.M. El-Wakil, *Power Plant Technology*, McGraw Hill Education, 2002.

ME1758

Renewable Energy Systems

[3 0 0 3]

Introduction, Different forms, Sources, Need for renewable energy sources, Solar energy: Sun as source of energy, Solar air heaters, Cooking, Drying, Distillation, Space heating, Refrigeration, Power generation: Low, medium and high temperature cycle, Measurement of solar radiation, 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, Energy Storage: Different modes of energy storage, Phase change materials, Selection criteria of PCMs, classification of PCMs.

Text Books:

1. S.P. Sukatme, *Solar Energy Principles of Thermal Collection and Storage*, McGraw Hill Education, 2nd Edition, 2005.
2. G.D. Rai, *Non-conventional Energy Sources*, Khanna Publications, 2004.
3. H.P. Garg and J Prakash, *Solar Energy: Fundamentals and Applications*, McGraw Hill Education, 1st Edition, 2017.

Reference Books:

1. S. Rao and Dr. B.B. Parulekar, *Energy Technology*, Khanna Publishers, 2004.
2. A.W. Culp, *Principles of Energy Conversion*, McGraw Hill Education, 2001.

ME1759

Aerodynamics

[3 0 0 3]

Review of potential flow, Method of images, Source panel method, Thin airfoil theory, Symmetric/Cambered airfoils, flapped airfoil, Vortex panel method, Wings: Down wash and induced drag, Elliptic and general lift distribution, Twisted wing, Numerical methods for wings, Basics of compressible flow and thermodynamics, One dimensional compressible flow, Normal and oblique shock waves, Expansion waves, Linearized compressible flow, Compressibility corrections, Wing body combinations.

Text Books:

1. A.M. Kuethe and C.Y. Chow, *Foundations of Aerodynamics*, Wiley, 5th Edition, 1997.

2. A. Motes, *Physics of Flight: An Introduction*, AM Photonics, 4th Edition, 2016.

Reference Book:

1. R.T. Hill, *Basic theories of Aeronautics*, Raymond T Hill, 3rd Edition, 2014.

ME1760

Computational Fluid Dynamics

[3 0 0 3]

Introduction: Conservation equations, Mass, Momentum and Energy equations, Convective forms of the equations and general description. Transformation from non-conservative form to conservative form, Classifications of boundary conditions, Implementation of boundary conditions in CFD, Staggered Grid, Flow chart and discussion. Navier-Stokes equations: Explicit and implicit methods, SIMPLE type methods. Discretization process: Concept and structure, Finite Difference Technique, Finite Element Method, Finite Volume Technique.

Text Books:

1. J.D. Anderson Jr., *Computational Fluid Dynamics- The Basics with Applications*, International Edition, McGraw Hill Education, 1st Edition, 1995.
2. S.V. Patankar, *Numerical Heat Transfer and Fluid Flow - Hemisphere*, CRC Press, 2017.
3. H.K. Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics-The Finite Volume Method*, Prentice Hall, 2nd Edition, 2007.

Reference Books:

1. K. Muralidhar and T.Sundararajan, *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, 2009.
2. D.A. Anderson, J.C.Tannehill, and R.H.Pletcher, *Computational Fluid Mechanics and Heat Transfer*, Taylor and Francis Group, 1997.

OPEN ELECTIVES:

ME 1491

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, melle 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.

Text Books:

1. G.C.Y. Wane, *Nanostructures and Nanomaterials*, World Scientific Publishing, 2nd Edition, 2011.
2. C.P. Poole and F.J. Owens, *Introduction to Nanotechnology*, Wiley India Pvt. Ltd, 1st Edition, 2007

References:

1. T. Pradeep, *Nano: The essentials*, McGraw Hill Professional, 1st Edition, 2008.
2. R. Kelsall, *Nanoscale Science and Technology*, John Wiley & Sons, 1st Edition, 2005.
3. A.S. Edelstein and R.C. Cammarata, *Nanomaterials: Synthesis, properties and applications*, Institute of Physics, 1st Edition, 1996.

ME 1492

SMART MATERIALS

[3 0 0 3]

Introduction to Smart Materials; High bandwidth - Low strain generating (HBLS) Smart Materials: Piezoelectric materials, Magnetostrictive materials; Actuators based on HBLS Smart Materials – Current Trends for Actuators and Micro mechatronics: Piezoelectric actuators, Magnetostrictive actuators, MEMS based actuators. Low bandwidth - High strain generating (LBHS) Materials: Shape Memory Alloys (SMA); Actuators based on LBHS Smart Materials: Shape Memory Alloy based actuators for shape control and Electro-active Polymers (EAP) for Work-Volume Generation; Sensors based on HBLS Smart Materials: Piezoelectric sensors, Magnetostrictive sensors, Techniques of self-sensing, MEMS sensors; Sensors based on LBHS Smart Materials: EAP based sensors, SMA based encoders, Optical fibre based sensing; Integration of Smart Sensors and Actuators to Smart Structures: Finite element modelling, Optimal placement of sensors and actuators, Design of controller for smart structure, Case studies to advanced smart materials

Text book:

1. B. Culshaw, *Smart Structures and Materials*, Artech House, 1st Edition, 1996.

Reference Books:

1. A.V.V. Srinivasan and D.M. McFarl, *Smart Structures Analysis and Design*, Cambridge University Press, 1st Edition, 2000.
2. M.V. Gandhi and B.D. Thompson, *Smart Materials and Structures*, Chapman and Hall, 1st Edition, 1992.

ME1592

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.

Text Books:

1. H.B. Cary, *Modern Welding Technology*, Prentice Hall Publishers, 3rd Edition, 1993.
2. P.T. Houldcroft, *Welding Process Technology*, Industrial Press Inc., 1998.

Reference Books:

1. V.M. Radhakrishnan, *Welding Technology and Design*, New Age International Pvt Ltd, 2nd Edition, 2005.

ME1593

Modern Manufacturing

[3 0 0 3]

Advanced Machining Processes: Mechanical Energy Based Processes: AJM, WJM, AWJM and USM. Electrical Energy Based Processes: EDM & WEDM. Chemical and Electro-Chemical Energy Based Processes: CHM and ECM. Thermal Energy Based Processes: LBM, PAM, EBM. Advanced Casting Processes: Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting. Advanced Welding Processes: Electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW). Advanced Metal Forming Processes: Electro-magnetic forming, explosive forming, Electro-hydraulic forming. Rapid Prototyping.

Text Books:

1. S. Kalpakjian, *Manufacturing Engineering and Technology*, Addison Wesley Longman, 4th Edition, 2002.
2. A. Ghosh & A.K. Malik, *Manufacturing Science*, Affiliated East West Press Pvt. Ltd., 2nd Edition, 2010.

Reference Book:

1. P.C. Pandey and H.S. Shan, *Modern Machining Processes*, McGraw Hill Publication, 1980.

ME1594**Designing for Automation****[3 0 0 3]**

Automation in production systems, Automation principles and strategies, Levels of automation, Automation at device level. Pneumatic Control: Production, distribution and conditioning of compressed air, Pneumatic control components, Pneumatic actuators, Pneumatic valves, Air-hydraulic equipment, Pneumatic control system design, Logic control circuits, Pneumatic circuit design for various applications. Hydraulic Control: Components of hydraulic control system, Hydraulic actuators, Hydraulic valves, Accumulators, Hydraulic circuit design and analysis. Electrical Control: Electrical actuators: Stepper motors, DC and AC motors, Motor selection. System Model Analysis: System model analysis, Model formulation, Transfer functions, System response, Linear system analysis. Programmable Logic Controllers: PLC system overview, PLC features, Basic PLC programming, PLC selection, Examples of PLC industrial applications.

Text Books:

1. M.P. Groover, *Automation Production Systems and Computer-Integrated Manufacturing*, Pearson Publication, 2014
2. A. Esposito, *Fluid Power with Applications*, Pearson Publication, 2003

ME1595**Industrial Metrology****[3 0 0 3]**

Linear Measurement Instruments, Interval measurements: Slip gauges, Optical flat. Measurement of Force, Torque and Strain: Torsion bar dynamometer, absorption dynamometers. Need for Inspection, Accuracy and Precision, Objectives, Standards of measurements. Metrology of gears: Measurement of tooth thickness: Gear tooth vernier, Constant chord method, Base tangent method. Measurement of tooth profile: Tool maker's microscope or projector. Measurement of concentricity, Alignment of gears. Screw Thread Measurement: Errors in threads, screw thread gauges, thread calliper. Metrology of Surface finish: Method of measuring surface finish: Stylus system of measurement.

Text Book:

1. A.K. Bewoor & V. Kulkarni, *Metrology & Measurement*, McGraw Hill Publication, 2012.

Reference Book:

1. N.V. Raghavendra & L. Krishnamurty, *Engineering Metrology & Measurements*, Oxford Publications, 2013.

ME1596**Introduction to Computer Graphics****[3 0 0 3]**

Introduction: Recent development in Computer Graphics, Scope, Graphic standards and hardware requirements for interfacing. Raster scan graphics, fundamental requirement and plotting of a point. Geometric Algorithm: Line drawing, DDA and Bresenham's line algorithm, circle generation using Bresenham's algorithm. Geometric Transformation: Two-dimensional transformation, basic and inverse geometric transformations, clipping and clipping algorithms. Elements of 3-D Graphics. Curve, surface and Solid: Projections, representations of polygons and solid modeling. Development of curves and surface using Bazier, Hermiye and B-spline algorithms. Evaluation of Curves length, surface area and

volume of objects of visual realism. Hidden line removals. Introduction and Application of Software packages.

Text book:

1. R.F. Davidand and J.A. Adams, *Mathematical elements for Computer Graphics*, McGraw Hill Publication, 2nd Edition, 2002

References:

1. I. Zeid and R. Sivasubramanian, *CAD/CAM Theory and Practice*, McGraw Hill Publication, 4th Edition, 2009
2. A. Edward, *Interactive Computer Graphics*, Pearson Education, 5th Edition, 2012.

ME1692

Non Destructive Testing

[3 0 0 3]

Scope and advantages of NDT, Comparison of NDT with DT, classifications of NDT. Visual Inspection Equipment. Eddy Current Testing: Principle, Advantages, Disadvantages, Factors Affecting Eddy Current Response, Applications, limitations. Liquid Penetrant testing: Liquid penetration testing, Principle, Equipment, Procedures, Characteristics of penetrants, developers. Magnetic particle testing: Principle of Magnetic Particle Testing, different methods to generate magnetic fields, Magnetic Particle Testing Equipment, Magnetic Particle Testing Procedures. Radiographic testing: X-ray radiography principle, equipment. Type of industrial Radiation sources and Application, Radiographic exposure Factors and Technique, GAMA Ray and X-Ray Equipment, Radiography Image Quality Indicators, Radiographic Techniques, Film Processing. Precautions against radiation hazards. Ultrasonic testing: Introduction, Principle of operation.

Text book:

1. J. Prasad, C. G. K. Nair, *Non-Destructive Testing and Evaluation of Materials*, McGraw Hill Publication, 2nd Edition, 2011.

Reference Book:

1. American Metals Society, *Non- Destructive Examination and Quality Control*, Metals Hand Book, Vol. 17, 9th Edition, 1989.

ME1693

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. Failure Rate and Degradation; Repairable and Non-Repairable Systems; Replacement Theory; Reliability data and censoring Approaches; Markov Model. Probability Distributions and Distribution Models: Discrete and Continuous Distribution; Normal Distribution; Exponential Distribution; Weibull Distribution; Gamma Distribution;

Lognormal Distribution. Point, mission and steady state availability, Availability assessment. Maintainability and its assessment, design for reliability and maintainability.

Text Books:

1. C.E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, McGraw Hill Publication, 2000.
2. L.S. Srinath, *Reliability Engineering*, Affiliated East-West Press Pvt. Ltd., 2005.
3. S.S. Rao, *Reliability Engineering*, Pearson Publication, 2016.

Reference Books:

1. A. Haldar and S. Mahadevan, “*Probability, Reliability and Statistical Methods in Engineering Design*”, John Wiley Publication, 1999.
2. K.C. Kapoor and L.R. Lamberson, *Reliability in Engineering Design*, John Wiley Publication, 2015
3. E. Balagurusamy, *Reliability Engineering*, McGraw Hill Publication, 1985

ME1694 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, Solar systems, Energy conservation in buildings. 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.

Text Book:

1. W.C. Turner, *Energy Management Handbook*, Fairmont Press Inc., 6th Edition 2007.

Reference Books:

2. D. R. Patrick, S.W. Fardo, *Energy Conservation Guidebook*, CRC Press, 2nd Edition 2007.
3. C.B. Smith, *Energy Management Principles*, Pergamon Press, 2nd Edition, 2015.

ME1695 Theory of Combustion and Emissions [3 0 0 3]

Introduction of combustion systems (internal combustion engines, gas turbines and boiler furnaces), Thermodynamics of Combustion, Enthalpy of combustion products, adiabatic flame temperature, Effects of flue gas recirculation, Gaseous fuel flames, laminar and turbulent premixed flames, explosion limits, flame ignition and quenching, Combustion of liquid fuels: fuel spray (formation and size distribution), simple model of droplet burning, Combustion of solid fuels: simple models of carbon combustion. Pollutant Formation and Emission Control in Boiler Furnaces: Carbon oxides, Sulphur oxides, controlling technology, Particulate matter: sources and ash-collecting systems (ESP, bag-house), Nitrogen oxides: formation mechanisms (thermal, fuel and prompt NO), principles and techniques of combustion-related NO_x control, post- combustion NO_x control. Emission Control in Internal Combustion Engines, emission standards in IC engines.

Text Book:

1. J. B. Heywood, *Introduction to Internal Combustion Engines*, McGraw Hill Publication, 2011.

Reference Books:

1. S.R. Turns, *An Introduction to Combustion: Concepts and Applications*, McGraw Hill Publication, 3rd Edition 2013.
2. K. K. Kuo, *Principles of Combustion*, John Wiley Publication, 2nd Edition, 2005.

ME1696**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 and non-traditional optimization techniques: Genetic Algorithms, Simulated Annealing, Tabu search methods. 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.

Text books:

1. S.S. Rao, *Optimization Theory and Applications*, John Wiley Publication, 2009.
2. R.L Fox, *Optimization Methods for Engineering Design*, Addison-Wesley Publication Co., 1971.

Reference Book:

1. C. Ray, *Optimum Design of Mechanical Elements*, John Wiley Publication, 2nd Edition, 1980.

ME1791**Quality Management****[3 0 0 3]**

Quality and its concepts, 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.

Text Books:

1. D.C. Montgomery, *Introduction to Statistical Quality Control*, John Wiley & Sons Inc., 6th Edition, 2008.
2. M. Mahajan, *Statistical Quality Control*, Dhanpat Rai, 2016.

Reference Books:

1. E.L. Leavenworth, S. Richard and Grant, *Statistical Quality Control*, 7th Edition, McGraw hill Education, 1972.
2. B.L. Hansen and P.M. Ghare, *Quality Control and Application*, Prentice Hall, 1st Edition, 1987.

ME1792

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.

Text Books:

1. S.N. Chary, *Production and Operations Management*, McGraw Hill Education, 6th Edition, 2015.
2. S.S. Buffa, *Modern Production Management*, John Wiley, 8th Edition, 2007.

Reference Books:

1. J.G. Monks, *Operation Management*, McGraw Hill Education, 2nd Edition, 1996.
2. J.S. Martinich, *Production & Operations Management*, John Wiley, 2008.
3. A.B. Badiru, *Industrial & Systems Engineering*, CRC Press, 2nd Edition, 2013.

ME1793

Engineering Economy

[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.

Text Books:

1. G.J. Tiesen and H.G. Tiesen, *Engineering Economy*, Prentice Hall of India, 4th Edition, 1975.
2. P.L. Mehta, *Engineering Economics*, Sultan Chand & sons, 2013.

Reference Books:

1. E.L. Grant, W.G. Ireson and R.S. Leavenworth, *Principles of Engineering Economy*, John Wiley, 1990.
2. L. Blank and A. Tarquin, *Engineering Economy*, McGraw Hill Education, 7th Edition, 2011.
3. J.L. Riggs, D.D. Bedworth and S.U. Randhawa, *Engineering Economics*, McGraw Hill Education, 4th Edition, 1996.

ME1794

Production Planning and Control

[3 0 0 3]

Introduction to production planning & control, Introduction to Forecasting: Simple & Weighted moving average methods, Exponential smoothing, Inventory control models: Economic Order Quantity (EOQ), Economic Batch Quantity (EBQ), Aggregate planning: Basic concept, its relations with other decision areas, Decision options: Basic & mixed strategies, Production Control Systems: Loading and scheduling, Master scheduling, Gantt charts, Johnson algorithm for n-jobs m-machines, Line balancing, Production control systems: Periodic batch control, MRP, MRP II, Kanban, JIT, Poka Yoke.

Text Books:

1. S.N. Chary, *Production and Operations Management*, McGraw Hill Education, 6th Edition, 2015.
2. S.S. Buffa, *Modern Production Management*, John Wiley, 8th Edition, 2007.

Reference Books:

1. J.G. Monks, *Operation Management*, McGraw Hill Education, 2nd Edition, 1996.
2. J.S. Martinich, *Production & Operations Management*, John Wiley, 2008.
3. A.B. Badiru, *Industrial & Systems Engineering*, CRC Press, 2nd Edition, 2013.

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