

Syllabi for Mechanical Engineering**ME10602 Mechanics****(3-1-0-4)**

Force systems: Moment of a force about a point and about an axis; couple moment; reduction of a force system to a force and a couple.

Equilibrium: Free body diagram; equations of equilibrium; problems in two and three dimensions; plane frames and trusses.

Friction: Laws of Coulomb friction, problems involving large and small contact surfaces; square threaded screws; belt friction; rolling resistance.

Kinematics and Kinetics of particles: Particle dynamics in rectangular coordinates cylindrical coordinates and in terms of path variables; central force motion.

Properties of areas: Moments of inertia and product of inertia of areas, polar moment of inertia, principal axes and principal moments of inertia.

Concept of stress and strain: Normal stress, shear stress, state of stress at a point, ultimate strength, allowable stress, factor of safety; normal strain, shear strain, Hooke's law, Poisson's ratio, generalized Hooke's law; analysis of axially loaded members.

Torsion: Torsion of cylindrical bars, torsional stress, modulus of rigidity and deformation.

Flexural loading: Shear and moment in beams; load, shear and moment relationship; shear and moment diagrams; flexure formula; shear stress in beams; differential equation of the elastic curve, deflection of beams.

Transformation of stress and strain: Transformation of stress and strain, principal stresses, principal strains, Mohr's circle for stress and strain.

Combined loading: Axial and torsional; axial and bending; axial, torsional and bending.

Column: Buckling of slender columns, Euler buckling load for different end conditions.

Books:

Vector Mechanics for Engineers, F.P. Beer and E.R. Johnston, Tata McGraw-Hill (7th Edition)

Reference books;

Engineering Mechanics, Irving H. Shames, Prentice Hall of India

Engineering Mechanics, J.L. Meriam and L.G. Kraige, John Wiley and Sons

Books:

Mechanics of deformable bodies, E.P. Popov

Reference books:

Mechanics of materials, F.P. Beer and E.R. Johnston

Mechanics of materials, Timoshenko and Gere

Introduction to solid mechanics, Irving H. Shames

Strength of materials, William A Nash

Elements of strength of materials, Timoshenko and Young

ME13601 Introduction to Manufacturing Processes (1-0-3-3)

Theory Component : Basic concepts and principles of manufacturing

Pre-forming processes: Casting, forging, rolling, drawing, extrusion, press tool work, plastic moulding and powder metallurgy.

Joining processes: Welding, brazing and crimping Semi-finishing and finishing processes : Machining (Turning, shaping, drilling, Milling and grinding).

Non-traditional processes: Abrasive jet machining, Ultrasonic machining, Electro-discharge machining, Electro-chemical machining and laser beam machining.

Product Quality: Possible defects and their detection, assessment and remedy.

Laboratory Component : Suggested Assignments

Machining :

1. Introducing to various machine tools and demonstration on machining
2. Making a steel pin as per drawing by machining in centre lathe
3. External screw thread by single point chasing in lathe
4. Making a cast iron Vee block by shaping
5. Making a regular polygon prism (MS) by milling
6. Making a gauge as per drawing
7. Study of machining in machining in machining centre (CNC) and Electrodischarge machining (EDM)

Foundry Practice

8. Orientation, demonstration and practice on metal casting
9. Practicing sand moulding using split and uneven parting line pattern
10. Practice on CO2 moulding and machine moulding
11. Mechanised sand preparation and melting practice

Welding Practice

12. Practice on Oxy-acetylene gas welding and manual metal arc welding (running bead)
13. Practice on oxy-acetylene gas cutting and arc welding for butt welding
14. Introduction and demonstration on submerged arc welding and plasma spray coating

Metal Forming

15. Demonstration of deep drawing process

Books:

Principles of Manufacturing Materials and Process, J S Campbell, Tata McGraw Hill
 Processes and Materials of Manufacture, Roy A Lindberg, Printice Hall of India Pvt. Ltd.
 Manufacturing Engineering and Technology, S Kalpakjian, Addison Wesley Publishing Company
 Materials and Processes in Manufacturing, E P DeGarmo, J T Black, R A Kohser, Prentice Hall of India Pvt. Ltd.

ME20601	Fluid Mechanics	(3-1-0-4)
Prerequisite: ME10602		
<p>Introduction - properties of fluids, concept of continuum, pressure and stress tensor</p> <p>Fluid statics - pressure variation in a static fluid, force on submerged surfaces, stability of floating bodies</p> <p>Kinematics - Lagrangian and Eulerian description, streamline, streakline and pathline, acceleration of a fluid element, continuity equation, stream-function, rotation and angular deformation, irrotational flow, velocity potential</p> <p>Inviscid flow - Euler equation, Bernoulli's equation and its applications</p> <p>Reynolds transport theorem - conservation of mass, linear and angular momentum</p> <p>Stokes law of viscosity and Navier-Stokes equations - some exact solutions</p> <p>Dimensional analysis and similarity - Buckingham Pi theorem</p> <p>Internal flows - pipe flow, friction factor, Moody diagram, minor and major losses, pipe networks, hydraulic diameter</p> <p>External flows - boundary layer approximation, momentum integral method, flow over a flat plate, flow separation</p> <p>Turbulence - Reynolds' experiment, Reynolds decomposition, time averaged</p> <p>Navier-Stokes equation, eddy viscosity</p> <p>Potential Flow - elementary plane flow solutions, Magnus effect</p> <p>Fluid Machinery - similarity, Euler equation for turbomachines, centrifugal pump, hydraulic turbines, cavitation</p>		
ME20602	Thermo-Fluid Science	(3-1-0-4)
Prerequisite: ME10602		
<p>INTRODUCTORY CONCEPTS: System and Control Volume, Thermodynamic Properties, Concept of Thermodynamic equilibrium, Properties of Fluids, Reynolds transport Theorem and its applications to system/control volume analysis.</p> <p>THERMODYNAMICS: First Law of Thermodynamics for closed and open systems, Second Law of Thermodynamics, Entropy, Change in entropy in various thermodynamic processes and concept of entropy generation, Exergy (Availability) balance for closed an open system, 2nd law efficiency, Vapour Cycles: Carnot cycle; Simple Rankine cycle, Reheat and Regenerative cycles; Ideal vapour compression refrigeration cycle. Air Standard Cycles: Carnot, Otto, Diesel and Brayton cycle.</p> <p>FLUID MECHANICS: Kinematics of fluid motion- Lagrangian and Eulerian description, streamline, streakline and pathline, acceleration of a fluid element, continuity equation, stream function, rotation and angular deformation, irrotational flow, velocity potential, Stokes law of viscosity and Navier-Stokes equations - some exact solutions Dimensional analysis and similarity - Buckingham Pi theorem, Internal flows – pipe flow, friction factor, Moody diagram, minor and major losses, hydraulic diameter, External flows - boundary layer approximation, momentum integral method, flow over a flat plate, flow separation</p>		

ME20604	Dynamics	(3-1-0-4) <i>Prerequisite: ME10602</i>
<p>Kinematics of particles: representation of motion of particles in various coordinate systems, relative motion in translating frames, constrained motion. Kinetics of particles: Concept of an inertial frame and Newton's second law, equations of motion for unconstrained and constrained motion, work-energy relation, conservation of energy, conservative and non-conservative forces, potential energy, impulse-momentum relation, angular momentum, conservation of momentum, d'Alembert's principle. Applications: central force motion, impact. Kinetics of a system of particles: Newton's second law, work-energy relation, impulse-momentum relations, conservation laws, steady and variable mass flow systems. Plane kinematics of rigid bodies: Kinematics of rigid bodies, instantaneous center of rotation, kinematics in rotating frames and relative motion. Plane kinetics of rigid bodies: Linear and angular momentum, equations of motion, work-energy relation, impulse-momentum relation, conservation laws. Introduction to spatial dynamics of rigid bodies: Kinematics in rotating frames and relative motion, angular momentum, kinetic energy, equations of motion, special cases of parallel-plane motion, and gyroscopic motion.</p>		
ME 20606	Kinematics of Machines	(3-1-0-4) <i>Prerequisites- ME 10602</i>
<p>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 criterion and inversions, displacement analysis, relative instantaneous centers, Aronhold-Kennedy theorem, velocity and acceleration analysis. Dimensional synthesis of planar mechanisms: three position synthesis for function generation, path generation and rigid body guidance, dead center problems, branch and order defects. Cams: synthesis of translating flat-face, translating roller and oscillating roller follower cams. Gears: fundamental law of gearing, characteristics of involutive action, analysis of gear trains. Spatial kinematic chains and robot kinematics: kinematic analysis of spatial chains, Denavit-Hartenberg parameters, robot kinematics.</p>		

ME 20608	Mechanical Measurements	(2-0-0-2)
Prerequisite: ME10602		
<p>Basic Concepts of Mechanical Measurements, Static and Dynamic Characteristics of Signals, Measurement System Behavior, Uncertainty and Error Analysis, Analog Electrical devices and measurements, Sampling, Digital Devices and Data Acquisition, Temperature Measurements, Pressure and Velocity Measurements, Flow Measurements, Strain Measurement, Metrology, Motion, Noise & Vibration, Force and Power Measurements.</p>		
ME20610	Mechanisms and Machines	(3-1-0: 4)
Prerequisite: ME10602		
<p>Introduction to mechanisms: Definitions, Kinematic pairs, Kinematic diagrams, Classification of kinematic chains, Kinematic inversion, equivalent linkages. Kinematic analysis of planar mechanisms: Mobility analysis and range of movement, Grashof criterion and inversions, displacement analysis, relative instantaneous centers, Aronhold-Kennedy theorem, velocity and acceleration analysis. Introduction to mechanism synthesis for path and motion generation. Cams: Analysis and synthesis of translating flat-face, translating roller and oscillating roller follower cams. Gears: Fundamental law of gearing, characteristics of involutive action, analysis of gear trains. Dynamics of machines: Dynamic analysis of planar mechanisms. Introduction to spatial kinematic chains and robot kinematics: Matrix method of analysis of spatial kinematic chains, Robot kinematics.</p>		
ME20612	Thermodynamics	(3-1-0-4)
<p>Introduction: Fundamental concepts and definitions, Temperature and Zeroth law, Thermodynamic properties and use of tables of thermodynamic properties; properties of simple compressible pure substances, Thermodynamic concept of energy, Modes of work and heat transfer. First Law of Thermodynamics: 1st law for closed and open systems and its applications. Second Law of Thermodynamics: The directional constraints on natural processes, Formal statements, Entropy and its changes in various thermodynamic processes, entropy generation. Exergy (Availability): Concept of reversible work, irreversibility and availability, Exergy balance in closed and open systems, 2nd law efficiency. Thermodynamic Property Relations: Maxwell relations, Clausius-Clapeyron equation, Generalized expressions for internal energy, enthalpy, and specific heats. Introduction to Properties of Mixtures and Phases: Ideal gas mixtures and their properties. Partial molal properties, Changes in volume, enthalpy, entropy and free energy due to mixing in a two-component system, Conditions of phase equilibrium and chemical equilibrium of multi-component systems, Gibbs phase rule. Thermodynamics of Reactive Systems: First law analysis of reactive system, Internal energy and enthalpy of reaction, Enthalpy of formation, Reaction equilibrium and equilibrium constant. Vapour Cycles: Carnot cycle, Simple Rankine cycle, Reheat and Regenerative cycles with feedwater heating, Ideal vapour compression refrigeration cycle. Air Standard Cycles: Carnot, Stirling, Ericsson, Otto, Diesel, and Dual cycles, Brayton cycle with intercooling, reheating and regeneration.</p>		

ME23601	Workshop Processes – II	(1-0-3-3)
<p>The lecture component will comprise of the explanation of various features of the processes related to the experiments.</p> <p>Selected jobs for practicing:</p> <p>Machining: facing, drilling, boring, turning-straight, taper, eccentric, grooving, thread cutting, forming etc. in centre lathes surfacing, making regular polygons and cutting gear teeth in milling machines gear teeth generation in gear shaping machine and hobbing machine part programming and machining in CNC machining center setting and operation of EDM finishing by grinding Measurement of dimensions, forms and surface finish of machined products.</p> <p>Foundry Technology: The practice-cum-experiments to impart an understanding on the various steps in metal casting including pattern design, sand preparation, moulding and melting: (a) Study on various types of patterns and pattern materials (b) Layout of a pattern (a) Study on sand preparation (b) Study on variation of mould properties with different moulding machines Study on the effect of moulding parameters on the properties of moulds Study of melting furnace and melting of aluminium alloys including degasification.</p> <p>Welding: Practical classes designed with the objective of imparting hands on training as well as understanding of welding technology. Suggested exercises are: Understanding of welding machine characteristics and controls, electrode specifications, selection of electrode size and current, laying of beads. Study of joint configuration and specification, required edge preparations; practice on preparing both side square groove butt weld; grinding of weld crown to make bead flush with plate surface; visual inspection of defects and reporting. Study of various types of oxy-acetylene flames; practice on flame adjustment, gas welding/brazing. Study and practice on submerged arc welding/ MIG welding.</p>		
ME29602	Mechanism Sessional	(0-0-3-2)
<p>Graphical methods of kinematic analysis and synthesis of mechanisms, and cams.</p>		
ME30601	Mechanics of Solids	(3-1-0-4)
<p>Prerequisite: ME10602</p> <p>Introduction of theory of elasticity- Analysis of Stress and Strain, Stress equation of equilibrium, Compatibility equations, Stress-Strain Relations, Solution of elasticity equations-stress function approach.</p> <p>Theories of failure- Yield criteria. Energy methods- Generalized forces and displacements, Reciprocal Theorem, Maxwell-Betti-Raleigh reciprocal theorem, Castigliano's theorems, Theorem of virtual work.</p> <p>Bending of Beams- Straight and asymmetrical bending, Shear center, bending of curved beams, Deflection of thick curved beams. Axisymmetric problems- Thick walled cylinders subjected to internal and external pressures-Lame's equation, Stresses in composite tubes-Shrink fits, Rotating discs with uniform and variable thickness, Rotating shafts and cylinders.</p> <p>Columns and struts- Euler's Buckling load, Different end conditions, Beam columns, Energy methods in buckling problems.</p>		

ME30602	Design of Machine Elements	(3-0-0-3)
Prerequisites: ME20604, ME20606, ME30601		
<p>General Principles of Machine Design; Engineering materials; Manufacturing considerations in Design; Design against static and fluctuating loads; Fasteners, Welded joints; Shaft, Keys, Couplings, Helical and Leaf springs, Clutches, Brakes, Rolling element Bearings & Journal bearings, Fly Wheel, Belt drive, Chain drive, Gear & Gear Trains.</p>		
ME 30603	Heat Transfer	(3-1-0-4)
Prerequisites: ME20601 or ME20602		
<p>Introduction, Modes of heat transfer, thermal conductivity, combined modes of heat transfer, concept of thermal contact resistance.</p> <p>Derivation of heat conduction equation, steady state one-dimensional heat conduction with and without generation of heat in simple geometries : plane wall, cylindrical and spherical walls, critical thickness of insulation, heat transfer from extended surfaces, 2D steady state heat conduction</p> <p>Unsteady conduction: lumped heat-capacity system, transient heat conduction in infinite and semi-infinite walls, concept of Heisler chart and Schmidt plot, heat conduction from a moving heat source.</p> <p>Forced convection: Derivation of energy equation, concept of thermal boundary layer and derivation of thermal boundary layer equation, flat plate in parallel flow (solution by energy integral method), cylinder in cross flow, internal flows: concept of thermally fully developed flow and its corollaries, fully developed pipe flow, fully developed channel flow with constant wall heat flux and viscous dissipation, turbulent flow in pipes, Reynolds analogy.</p> <p>Free convection: Vertical plate at constant temperature – derivation of governing equation, recognition of dimensionless terms, and solution by integral method, free convection in vertical channel.</p> <p>Condensation and Boiling: laminar film condensation over a vertical plate and horizontal circular tube. regimes of boiling heat transfer, correlations for heat flux in boiling.</p> <p>Heat exchangers: classification of heat exchangers, overall heat transfer coefficient, concept of fouling factor, LMTD and NTU methods of analysis for a double pipe heat exchanger, applications to multi-tube, multi-pass heat exchangers.</p> <p>Thermal radiation: Radiation properties, blackbody radiation, Planck’s law, Stefan-Boltzman law, Kirchoff’s law, radiation exchange between black surfaces, concept of view factor, radiation exchange between non-black surfaces, two-surface enclosure, three surface enclosure, concept of radiation shield.</p>		
ME30604	Machine Tool & Machining	(3-1-0-4)
Prerequisites: ME30605		
<p>Machine tools: Concept and definition of machining and machine tools. History of developments of machine tools. Concept of producing geometrical surfaces by generatrix and directrix. Kinematic systems and structures of conventional machine tools. Electromechanical and hydraulic drives and control of machine tools. Machine tool automation. Classification and specification of machine tools. Construction, working principle and application of various semi-automatic and automatic lathes. Flexible automation – need, principle and advantages. Basic constructional features, working principle and application of CNC machine tools, machining centre and FMS.</p> <p>Machining: Tool geometry, mechanism of chip formation. Mechanics of machining. Cutting temperature – causes, effects, estimation, measurement and control. Cutting fluid applications. Failure modes, wear and life of cutting tools. Cutting tool materials. Role of geometrical and process parameters and cutting fluid on machinability. Mechanics of grinding. Economy of machining and grinding. Special techniques and advanced technology of machining and grinding.</p>		

ME30605	Casting Forming & Welding	(3-1-0-4)
		Prerequisites: ME23601
<p>Casting: Types of foundries, steps in making a casting; cast metals; types, materials and allowances of patterns; moulding processes and their characteristics; moulding materials; gating and risering; melting furnaces; casting defects.</p> <p>Welding: Welding processes; welding energy sources and their characteristics; fluxes and coatings; weldability and welding of various metals and alloys; metallurgical characteristics of welded joints; weld testing and inspection.</p> <p>Forming: Classification of metal forming processes; basic metal working concepts and plasticity; yield criterion; slip line fields; estimation of force and energy requirements; technology of bulk and sheet metal forming processes; precision forming processes; various features of different types of metal forming dies; principles of powder forming.</p>		
ME 30606	Dynamics of Machines	(3-0-0-3)
		Prerequisite: ME20604, ME20606
<p>Basic concepts: Generalized coordinates, constraints and their types, degrees-of-freedom, discrete and continuous systems, conservative and non-conservative forces.</p> <p>Discrete systems: Equations of motion: Hamilton's principle and Lagrange's equation, considerations for constraints and non-conservative forces. Theory of small oscillations: Equation of motion, free response using complex vector representation of solution and transform methods, eigenvalue problem, characteristic equation, properties of inertia and stiffness matrices, concept of normal modes, their properties and expansion theorem, initial value problem, beat phenomenon, classical and non-classical viscous damping, other types of damping, forced vibration (undamped and damped) under harmonic and general forcing, frequency response function, resonance and Q-factor, logarithmic decrement, base excited vibration, tuned mass absorber and damper, critical speeds and whirling of shafts, field balancing of rigid rotors, Single cylinder engine balancing, Raleigh's method.</p> <p>Continuous systems: Equation of motion for transverse vibration of strings, axial vibration of bars, torsional vibration of shafts using Newtonian approach, transverse vibration of beams. Free vibrations and eigenvalue problem, normal modes, orthogonality and expansion theorem.</p>		
ME 30608	Applied Thermo-Fluids I	(3-0-0-3)
		Prerequisites- {(ME20601 & ME20612) or (ME20602)}, (ME30603)
<p><u>IC Engines</u>: Review of Otto, Diesel, Dual & Stirling Cycles. Comparison of cycles Classification of Engines. Testing and performance Characteristics—Heat balance, Indicators and Indicator Diagrams, Fuels and Fuel ratings, Fuel feed systems—Carburetor, Fuel injection systems, Fuel pump and injector. Ignition Systems—Battery and Magneto. Governing of I C Engines, Normal and abnormal combustion in S I and C I Engines, Design and operating Parameters affecting engine power, Economy and emissions. Air Pollution, Rotary Engines, Supercharging, Cooling, Lubrication and wear</p> <p><u>Refrigeration</u>: Thermodynamics of Refrigeration systems, Vapor Compression Refrigeration Systems, Single Stage Saturation (SSS) cycle, effects of sub-cooling and superheating, Gas cycle refrigeration systems, Vapour Absorption Refrigeration Systems, Refrigeration system components: Compressors. Expansion valves, Evaporators, and Condensers</p> <p><u>Air-conditioning</u>: Principles of psychrometry and psychrometric processes, Selection of indoor and outdoor design conditions, Thermal comfort, Cooling and heating load calculations, transmission and distribution of air</p>		

ME39601	Casting Forming & Welding Lab	(0-0-3-2)
<p>Casting: Practice on CAD of gating and risering Experiment to determine the effect of moulding variables in sand moulds To determine the effect of mould additive on the properties of castings To determine the characteristics of base sands.</p> <p>Welding Study of arc characteristics in simulated MMA welding; arc gap-arc voltage relationship; recording of voltage oscillograms and its study. Study of heat flow and temperature distribution in welding Study of characteristics of TIG/MIG welding Ultrasonic/dye penetrant inspection or computer simulation of welding heat flow/analysis of arc-voltage pattern.</p> <p>Forming Experiments on formability test, powder compaction; strip layout for progressive die design</p>		
ME 39602	Machine Design Practice	(0-0-3-2)
<p>Design Calculation and Drawings of the followings.</p> <p>Assignment 1: Generation of geometric profiles of gears and cams. (3hrs x 2) Assignment 2 : Dimensioning concept and detail drawing of machine components. (3hrs) Assignment 3: Design and drawing of a gear box (3hrsx4 to 5) Assignment 4: Design and Drawing of Brake or Clutch (3hrs. x 2) Assignment 5: Design of a pressure vessel/engine head (Mainly bolt joints) (3hrs)</p>		
ME 39603	Strength of Materials Laboratory	(0-0-3-2)
<p>Tension Tests, Impact Tests, Hardness Tests, Bending and Torsion Tests, Calibration of Proving Rings, Fatigue Tests, Strain Gage Experiments, Study of Photo-elastic Bench, Calibration of Photo-elastic materials, Wear of Materials.</p>		

ME39604	Machine Tool & Machining Lab	(0-0-3: 2)
<p>Machine Tools and Machining: <i>Machine Tool:</i> Acceptance test of machine tool (radial drilling machine) System compliance of machine tool (center lathe) <i>Machining:</i> Resharpener of turning tool to specific geometry Measurement of cutting forces and surface finish in turning, drilling and milling Measurement of cutting temperature and tool life in turning Measurement of grinding forces and surface finish in grinding Machine setting and operation for helical gear teeth cutting.</p> <p>Metrology: Inspection of straightness and flatness of surfaces Measurement of angles Measurement of external and internal taper Inspection of screw threads Inspection of gear teeth Measurement of roundness by Telerond Calibration of measuring instruments</p>		
ME39606	Thermo-Fluids Lab I	(0-0-3-2)
<p>Study of I.C. Engine models, Load test on a Petrol engine, Load test on a Diesel engine and Morse test on a multi-cylinder engine. Studies on refrigerant compressors. Experimental observations on a refrigeration test-rig. Performance evaluation of a vapour compression refrigeration system. Pull-down and cycling studies on a cold storage unit. Performance evaluation of an air conditioning system Pressure distribution for flow over a cylinder, measurement of velocity profile in the boundary layer, characteristics of a convergent-divergent nozzle and characteristics of a centrifugal fan.</p>		
ME40601	Systems and Control	(3-1-0-4)
<p style="text-align: right;">Prerequisites : ME20604, (MF20606 or ME20610), (ME30601)</p> <p>Need for unified approach to system modeling, Introduction to bond graphs, Power variables of bond graphs and models of simple circuits, Reference power directions, Bond graph elements and their constitutive relations, Causality, Generation of system equations from bond graph models. The Idea of activation & activated bonds. Art of creating system bond graphs, Bond graph models of structural ,hydraulic, and thermal systems, Approaching control systems, Signal flow graphs from bond graph models, Creation of transfer functions, Introduction to state space methods. The issue of stability and Routh's criterion, Root locus diagrams, Nyquist and Bode plots, Elements of control system design, Applications of modeling, simulation and controls software.</p>		

ME40603	Applied Thermo-Fluids II	(3-1-0 4)
Prerequisites- {(ME20601 & ME20610) or (ME20602)}, ME30603		
<p>Analysis of steam cycles, optimization of reheat pressure and degree of regeneration, coupled cycles and combined plants, process heat and power.</p> <p>Fuels and their properties, stoichiometric and actual air requirements, flue gas analysis, boiler energy balance, draft system. Different types of furnaces for burning coal, fuel oil and gas. Circulation theory, down-comers and risers, economizers and super-heaters, air pre-heater, drum and its internals. Different types of boilers, boiler mountings, feed water treatment, boiler loading and manner of operation.</p> <p>Steam turbines; convergent and convergent-divergent nozzles - theory and design. Impulse and reaction turbines, compounding of turbines, optimum velocity ratio, reheat factor and condition line, parallel exhaust, losses in steam turbines, steam turbine governing.</p> <p>Theory and design of condensers, air ejector and cooling tower.</p>		
ME41601	Computer Graphics & Solids Modelling	(3-0-0-3)
<p>Graphics output devices, Rasterization, scan conversion. Raster scan Graphics: Algorithms for rasterization of straight lines and circles. Display Generation Techniques: Real time scan conversion, Run-length encoding, Cell organization, Frame buffer memory. Curves and Surfaces: Splines, parametric curves, Bezier and B-spline curves and surfaces, ruled surfaces and surfaces of revolution. Solids and their properties: Surfaces and curves in solids, Intrinsic and global properties, Characteristic tests and Intersections.</p> <p>Solid Modelling: Data structures and Boolean operations. Computer Graphics Display Interface: Modelling transformations, Viewing transformations, Projections, Clipping, Hidden line/surface elimination, shading and light sources, Double buffering, Hardware graphics engines. Computer-aided drafting, Parametric drafting, Design visualization, Integration with NC machines and manufacturing. Scientific Visualization: Animation, physical principles. Graphics Standards: 2D and 3D standards and graphics portability</p>		
MF41601	Soft Computing	(3-0-0-3)
<p>Genetic Algorithms: introduction, mathematical foundation, computer implementation, genetic based machine learning, applications.</p> <p>Neural Networks: introduction, multi-layer networks, recurrent networks, learning paradigms. Fuzzy Control: an industrial perspective, knowledge based system for process control, mathematics of fuzzy control, non-linear and adaptive fuzzy control.</p> <p>Chaos: complexity and simplicity, evolution of possibilities, simple models of chaos, strange attractors, deterministic chaos, self-organisation, synergetics.</p> <p>Evolutionary Computing: hybrid intelligent system, evolutionary dynamics, evolutionary engineering and its application.</p> <p>p-component (Manufacturing software lab): Development of software for the control of network based distributed and real time systems using techniques based on Corba, Java and XML etc. Development of software for collaboration using agents and other approaches. Development of process control software using neural network, fuzzy logic, genetics and other emerging approaches.</p>		

ME41603	Vibration and Noise Control	(3-0-0-3) <i>Prerequisites: ME20604</i>
<p>Fundamentals of Vibration Theory; Force Transmissibility, Design of Vibration Isolators and Absorbers & other passive dampers; Active Vibration control; Torsional Vibration; Basics of Acoustics, Solution of 1-D and 3-D wave equation, Sound Field Characterization, Sound Sources, Principles of Noise Control, Reflection and Transmission of Sound Waves, Noise Control Materials: Absorbers, Barriers and Damping Materials, Silencers.</p>		
ME41605	Simulation of Mechanical Systems	(3-0-0-3) <i>Prerequisites: ME20604</i>
<p>Energy Methods and variational principles. Euler-Lagranges equation for discrete and continuous systems. Hamiltons principle. Analysis of constraints - non-holonomic systems. Integration of system equations. Modelling in multi-energy domain through bond graphs. Modelling of a system of rigid bodies, structural systems, Hydraulic systems, Thermal systems, electronic and mechatronic systems. Modelling systems for control strategies and design of control strategies in physical domain. Numerical prototyping as modelling for design and synthesis using computational tools like SYMBOLS, MATLAB, ADAMs, etc.</p>		
ME41606	Finite Element Methods in Engineering	(3-0-0-3) <i>Prerequisites: ME10602, 20604</i>
<p>Introduction-Basic Concept of FEM, Methods of weighted residual techniques-Weak Formulation, Galerkin FE formulation, Rayleigh & Ritz FEM,FEM analysis of One-dimensional problems:-Second order boundary value problem, Applications in Solid, Fluid and Heat Transfer, Bending of Beams, Euler-Bernoulli Beam, Truss/Frame analysis, Eigenvalue and Time dependent problems, MATLAB Application, Numerical Integration and Computer Implementation-Natural Co-ordinates, Interpolation Functions, Numerical Integration, Isoparametric Formulation, Computer Implementation, Applications in two-dimensional problems-Plane Stress and plane Strain, Three Dimensional Solid, Axi-symmetric Solid, Plate and Shell structures, Flow of Viscous Fluid, MATLAB Application, Special Topics, Stationary Singular elements, Quarter-Point Singular Elements, Moving singular elements, Semi-infinite elements, Buckling analysis, Non-linear analysis</p>		
ME41607	Composite Materials	(3-0-0-3)
<p>Introduction: materials, fiber reinforcement, matrix materials; Manufacturing processes: hand lay-up, prepeg lay-up, bag molding, autoclave processing, compression molding, resin transfer molding, pultrusion, filament winding, micro-mechanics: strength of materials approach, continuum approach; Ply mechanics: co-ordinate systems, off-axis stiffness; Macro-mechanics: description of laminates, laminate moduli, computation of stresses in laminates, types of joints. Failure criteria, Smart composites: active fiber composites, introduction to smart composite structures.</p>		

ME41608	Fatigue, Creep and Fracture	(3-0-0-3) Prerequisites: ME30601
<p>FATIGUE : Types of fatigue leading and failure, Fatigue test, endurance limit, S-N diagram; Various failure relations, Viz., Soderberg, Modified Goodman-, Gerber parabolic-, Elliptical-relations; Factors influencing fatigue strength; Influence of stress concentration on fatigue test; Fretting corrosion; Effect of environment-corrosion fatigue; Increased fatigue life due to surface protection.</p> <p>CREEP : Mechanics of creep, inter-granular, trans-granular creep, Creep test, Creep strain rate-time curves, Deformation mechanism map; High temperature properties of materials; Long time creep-stress-time relations; Creep contribution to the fracture mechanism; Creep contribution to the fracture mechanism; DVM, DVL German-standard, Hatfield time yield test.</p> <p>FRACTURE : Damage tolerance analysis, residual strength in presence of cracks; Mechanisms of crack growth and fracture; Basic modes of fracture; Stress Concentration factor, state of stress at a stress concentration, load-flow-times; Measurement of Collapse strength; Griffith's theory of brittle fracture; Irwin's theory of fracture in elastic-plastic materials; Theories of linear elastic plastic fracture mechanics (LEFM); Stress intensity fracture, toughness, stress distribution at crack tip: plane stress, plane strain cases; Theories of elastic plastic fracture mechanics (EPFM); Crack opening displacement (COD) Criterion, COD tests, crack tip opening displacement (CTOD) measurement; Crack arresters; Implementation of fracture control.</p>		
ME 41609	Airconditioning	(3-0-0-3) Prerequisite- ME20612
<p>Brief history of airconditioning. Principles of psychrometry, psychrometry of airconditioning processes, comfort chart, indoor and outdoor design conditions. Solar time, solar angles, direct beam and diffuse solar radiation, sol-air temperature. Equivalent temperature difference and time lag- decrement factor methods of cooling load calculations and psychrometric applications. Transmission and distribution of air, air-conditioning apparatus and control.</p>		
ME 41610	Automobile Engineering	(3-0-0-3)
<p>Introduction to Automobiles, Basics of Otto and Diesel cycle, Elements of Petrol and Diesel Engine, Engine Performance curves, Vehicle Performance Characteristics and Requirements, Power-train, Transmission and Drive units, Exhaust System and Emissions, Steering and Suspension System, Chassis and Body Design, Brake systems, Electrical and Lighting Systems, Safety and Comfort Features, Wheel and Tyre, NVH Considerations in Vehicle Design, Vehicle Ride and Handling Evaluation, Basics of Automobile Manufacturing, Electric and Hybrid Vehicles.</p>		
ME41611	Mechanical Handling Systems and Equipment	(3-0-0-3)
<p>Introduction to various Mechanical Handling Systems and Equipment for handling unit load and bulk materials, namely Pulley blocks, Winches, Electric Hoists, EOT Cranes, Belt Conveyor, Bucket Elevator, Screw conveyor and Pneumatic Conveyor etc. Dynamic analysis ,design procedures of their components, common mechanisms involved. and their industrial applications. Programmable and Flexible load handling devices.</p>		

ME 41612	Experimental Stress Analysis	(3-0-0-3) <i>Prerequisites: ME30601</i>
<p>Basic elasticity theory. Strain Measurement Methods: Various types of strain gauges, Electrical Resistance strain gauges, semiconductor strain gauges, strain gauge circuits, transducer applications, Recording instruments for static and dynamic applications. Photoelasticity: Theory of photoelasticity, Analysis techniques, Three dimensional photoelasticity, Reflection Palanscope and application. Brittle coating methods of strain indication. Moire' Method of strain analysis. Grid method of strain analysis, Computer interfacing and on-line monitoring of strain and stress fields.</p>		
ME41613	Design Optimization	(3-0-0-3)
<p>Formulation of Optimization Problems; Analytical Methods of Optimization; Numerical Methods: Unconstrained optimization of one Variable; Unconstrained optimization of Many Variables; Constrained Optimization of Many Variables: Linear and Nonlinear Programming; General Design Applications.</p>		
ME41614	Modern Control Theory	(3-0-0-3)
<p>Review of classical control concepts, State space and state variables, feedback and state variable equations, Controllability, Observability, Solutions in state space, Sampled data and digital systems, Stability in continuous and discrete time systems, Optimal control concepts - maximum principle, various performance indices, Regulators and filters, Introduction to structural control - various types of feed-backs, effects of collocation and non-collocation of actuator and sensors, etc., Design of controllers in state space</p>		
ME41615	Tribology	(3-0-0-3) <i>Prerequisites: ME30601</i>
<p>Definition of Tribology ; Surfaces: Nature, characterization and effects on friction lubrication and wear. Friction: Types of friction and mechanisms. Wear: Types of wear, Mechanisms, Wear Law Surface temperatures: Basic formulations, measurements. Lubrication: Regimes, Hydrodynamic and hydrostatic lubrication, Basic equations and their solution methodology. Lubricants: Types and Characterization, Boundary lubrication-solid lubricants, Additives. Experimental methods: Friction and Wear measurements, Types of measuring instruments. Friction and wear of polymers and composites: Types and uses, Friction and Wear Mechanisms Methods of improving tribological behavior: Case studies.</p>		

ME41616	Micro-scale fluid flow and heat transfer	(3-0-0-3)
Prerequisites: ME20601, ME30603		
<p>Introduction: Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions, continuum hypothesis and deviations from the same, scaling laws for micro-domains, Microscale gas flows: Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuille flows, effects of compressibility, introductory concepts on gas flows in transitional and free molecular regimes, some representative applications of micro-scale gas flows in accelerometers, micro-propulsion and micro-nozzles, Microscale liquid flows: Pressure driven liquid microflow, apparent slip effects, physics of near-wall microscale liquid flows, capillary flows, electro-kinetically driven liquid micro-flows and electric double layer (EDL) effects, concepts of electro-osmosis, electrophoresis and dielectro-phoresis, analysis of hydro-dynamically and thermally fully developed electro-osmotic flows, ac electro-osmosis, an introduction to fluid dynamics over nano scales (nanofluidics), concepts of nano-fluids and their augmented transport characteristics, An introduction to bio-microfluidics and some illustrative applications (drug delivery, DNA hybridization, leukocyte rolling etc.), An introduction to special computational modelling of micro-flows: MD and DSMC methods</p>		
ME 41618	Turbo-Machinery	(3-0-0 : 3)
Prerequisites - ME20601 and ME20612		
<p>Axial flow compressors: flow through cascades, cascade terminology, flow separation, radial equilibrium theory, actuator disc theory, effect of tip clearance, secondary flow, performance characteristics, surging and stalling. Axial flow turbine: vortex theory, blade design, cooling of turbine blades, performance characteristics. profile loss, secondary flow loss, annulus loss, tip clearance loss. limiting factors in turbine design. Applications: gas turbine power plant, aircraft propulsion.</p>		
ME41620	Fluid Power Control	(3-0-0-3)
Prerequisites: ME20001		
<p>Fundamental Concept of Fluid Power Transmission, Drive and Control . Oil Hydraulics:- Properties of conventional fluid; Power pack, valves, positive displacement pumps and motors, electro-hydraulic valves (servo and proportional control),symbols, circuit and systems. Pneumatics:- Compressible fluid properties; Components, symbols, circuit and applications Fluid Power and Control in Automation:- Fluid logic, applications. Special topics on fluid power and control applications.</p>		
ME49601	Thermo-Fluids Lab II	(0-0-3-2)
<p>Determination of heat transfer coefficient in fluidized bed combustion, Pressure drop and holdup studies for a fluidized bed, Determination of flame velocity and burner loading in premixed combustion of gaseous fuel and Determination of boiler efficiency and condenser heat transfer coefficient of a electrical boiler. Heat transfer through a lagged pipe, Forced convection heat transfer coefficient in a pipe, determination of reflectivity, emissivity, absorptivity and transmissivity, Nucleate pool boiling and effectiveness of parallel and Counter flow heat exchangers.</p>		

ME 60002	Convective Heat and Mass Transfer	(3-1-0-4) <i>Prerequisites- ME20601, ME30603</i>
<p>Energy equation for laminar and turbulent flows. Order of magnitude analysis and Reynolds analogy. Steady forced convection in Couette flow, Poiseuille , plane Poiseuille flow and Jeffery Hammel flow with and without viscosity variation. Leveque solution, Graetz problem. Thermal boundary layer, low Prandtl and high Prandtl number approximations. Thermal boundary layer over isothermal and adiabatic flat plate and wedge. Heat transfer from curved surfaces. Momentum integral methods. Free convection: boundary layer over vertical flat plate and cylinder- series and similarity solution. Free convection inside curved bodies and between parallel plates. Free convection over heated horizontal plate - Benard cells. Empirical correlations. Mixed convection, conjugate problems and moving boundary freezing and melting problems.</p> <p>Nucleate Pool boiling and forced convection boiling inside tubes under various flow regimes. Condensation: Nusselt film condensation theory, dropwise condensation and condensation inside tubes.</p>		
ME60003	Advanced Metal Casting Technology	(4-0-0-4)
<p>Casting Processes, classification, characteristics of sand casting processes, metal mould casting processes and casting processes using other mould/core materials, Pattern materials, types of patterns, Mould and core making materials and their characteristics Technology of Selected Casting Processes, clay bonded, oil bonded, synthetic resin bonded, inorganic material bonded mould and core making processes. Sand additives and mould coatings. Metal mould casting processes; centrifugal and continuous casting processes.</p> <p>Solidification, Gating and Riser, Nucleation and grain growth, Solidification of pure metals, short and long freezing range alloys. Rate of solidification, macrostructure and microstructure. Solidification contraction; gating and riser design calculations. Fluidity and its measurement. Mould-metal interface reactions.</p> <p>Cast Metals and Alloys, Family of cast irons, Melting and casting technology; Inoculation. Technology of steel and non-ferrous cast metals. Gases in metals. Melting furnaces and refractories.</p>		
ME60004	Advanced Welding Technology	(4-0-0-4)
<p>Physics of welding arc - characteristics of arc and mode of metal transfer, welding fluxes and coatings - type and classification; electrode codes and their critical evaluation; welding machine characteristics - conventional and pulsed power sources, inverter type, power sources for resistance welding, weldability - weldability of cast iron, plain carbon and low alloy steels, stainless steels, determination of preheat temperature, use of Schaeffler's diagram, weldability tests, heat flow in welding - significance, theory of heat flow, cooling rate determination, selection of welding parameters based on heat flow analysis, residual stress and distortion - theory of residual stresses and distortion calculation, welding codes, joint design, analysis of fracture and fatigue of welded joints - fracture, energy consideration, fracture toughness testing and its application to welded joints, automated welding systems; microprocessor control of arc welding and resistance welding, quality assurance in welding, welding fumes and their effect on the environment.</p>		

ME60022	Experimental Stress Analysis	(3-1-0-4)
<p>Basic elasticity theory. Strain Measurement Methods : Various types of strain gauges, Electrical Resistance strain gauges, semiconductor strain gauges, strain gauge circuits, transducer applications, Recording instruments for static and dynamic applications.</p> <p>Photoelasticity : Theory of photoelasticity, Analysis techniques, Three dimensional photoelasticity, Reflection Palanscope and application.</p> <p>Brittle coating methods of strain indication. Moire' Method of strain analysis. Grid method of strain analysis. Computer interfacing and on-line monitoring of strain and stress fields.</p>		
ME60023	Applied Elasticity and Plasticity	(3-1-0-4)
<p>Analysis of three dimensional stresses and strains. Tensor character of stress. Equations of equilibrium of a deformable body in curvilinear coordinates. Strain-displacement relations and compatibility conditions. Generalized Hooke's law. Plane problems in cartesian and polar coordinates. Axisymmetric formulations. Thermal stresses. Torsion.</p> <p>Yield criteria for ductile materials. Plastic stress-strain relationships. Plastic work and strain-hardening hypothesis.</p>		
ME60024	Tribology	(3-0-0-3)
<p>Introduction, economic aspects, lubrication of bearings, friction control and wear prevention. Properties and testing of lubricants. Mechanics of fluid flow - Reynolds equation and its limitations. Idealized bearings : Infinitely long plane pivoted shoe and fixed shoe sliders, Infinitely long journal bearings, Infinitely short (narrow) bearings, Lightly loaded infinitely long journal bearing (Petroffs' solution). Finite bearings : Approximate analytical solution, Numerical solution and Electrical analogy method. Hydrostatic oil bearings : Thrust and journal bearings. Squeeze film bearings. Gas-lubricated bearings; hydrodynamic bearings, hydrostatic bearings porous bearings. Elasto-hydrodynamic lubrication. Fluid inertia and turbulence and hydrodynamic instability. Friction and wear of metals.</p>		

ME60025 Metal Forming Processes**(4-0-0-4)**

Introduction of metal forming as a manufacturing process, and its relation with other processes, Metal Forming from systems point of view, Advantages of metal forming as a manufacturing process, Classifications of metal forming processes, Forming equipments, Presses (mechanical, hydraulic).

Theoretical analysis (theory of plasticity), Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation and extent of plastic flow (microstructural point of view).

Analysis of forming processes, Slab analysis: Open-die forging, Plate drawing, Flat rolling, Deep drawing of sheet, Other methods of analysis like FEM, upper bound, slip line field.

Overview of various metal forming operations: Forging; open-die forging, closed-die forging, coining, nosing, upsetting, heading, extrusion and tooling, Rod, wire and tube drawing, Rolling; flat rolling, shape rolling and tooling, Sheet forming; blanking, piercing, press bending, deep drawing, stretch forming, spinning, hydroforming, rubber-pad forming, explosive forming, Formability of sheet, Formability tests, Forming limit diagrams, Process simulation for deep drawing and numerical approaches.

Powdered metals and fabrication procedures, Applications, Preparation of powders, Compacting and sintering, Yield criteria and flow rules, Hot and cold pressing (HIP, CIP).

ME60033 Intelligent Machines and Systems**(4-0-0-4)**

Scope of machine intelligence in manufacturing systems - modeling and control of processes and machines.

Machine learning for system modeling from incomplete, ambiguous information. Neuro-Fuzzy-Expert systems for uncertain reasoning. Concept learning, associative memory and connectionist learning systems. Data abstraction in parallel distributed architectures. Model based optimization using evolutionary algorithms. Genetic algorithms.

Sensor-based Robotic systems for assembly, welding, machining etc. and mobile robots. Task level planning and path planning. Multi-sensor integration for environmental interaction and error recovery. Principles and applications of sensors - displacement, force, tactile, temperature, acoustic, vision and range sensors. Visuo-motor coordination and navigation problems. Intelligent structures. Behavioural approach and subsumption architecture for learning from environment.

ME60034	Manufacturing Resource Planning	(4-0-0-4)
<p>Introduction to Manufacturing Resource Planning,</p> <p>Inventory Control, Production Planning, Master Production Scheduling, Material Requirement Planning, Resource Planning, Rough Cut Capacity Planning, Capacity Requirement Planning.</p> <p>Scheduling, Job Shop Scheduling, Set-up dependent scheduling. Flow Shop Scheduling, Special techniques in scheduling. Application of Genetic Algorithm in Scheduling.</p> <p>Introduction to Just-in-Time, Scheduling in JIT.</p>		
ME60044	Industrial Automation & Control	(3-1-0-4)
<p>Basic principles of industrial automation. Role of mechanical handling in automation. Mechanical muscle power and control. Sequencing of operations. Kinematic analysis and design of some automatic machines, transfer mechanism using hydraulic and pneumatic circuits etc.</p> <p>Analog and digital signal coding. Data acquisition and processing, Microprocessor based instructions. Instrumentation and Computer interfacing. Object recognition and identification techniques like image processing etc.</p> <p>Application of robots and other intelligent machines in automation. On line quality control in automation.</p>		
ME60052	Mechatronics	(3-1-0-4)
<p>Basics solid state components and devices, elements of electromechanical energy conversion, starting, inversion and control of electrical drives, Coupling of mechanical loads to DC and AC electrical drives and speed control. Optoelectronic encoding, sensing, signal shaping and processing devices and techniques. Basics of digital signal processing data acquisition. Special simulation techniques for mechatronic systems, special techniques for solving of shift system model with switching and delay components. Elements of Telemetry and remote control of mechatronic systems, theory of linear observers, optimal filters and their digital implementations, design and implementation of digital control strategies for mechanical system.</p>		
ME60061	Automatic Control	(3-1-0-4)
<p>Introduction; Mathematical models of physical system; Feedback characteristics of control systems; Control systems and components; Time response analysis, design specifications and performance indices; Concepts of stability and algebraic criteria; Root locus technique; Frequency response analysis; Stability in frequency domain; Introduction to design; State variable analysis and design.</p>		
ME60063	Machine Vibration Analysis	(3-1-0-4)
<p>Characterization of Engineering vibration problems. Model study through single degree of freedom analysis. Two degrees and Multidegree of freedom systems with applications. Continuous medium, Vibration Measuring Instruments, computational Techniques like Matrix iterations, Transfer Matrix method and other methods, Lagrange's mechanics, system simulation technique.</p>		

ME60064	Nonlinear Vibration	(3-1-0-4)
<p>Introduction : Expansion, gauge functions, order symbols, asymptotic series and expansions; Qualitative and quantitative methods of conservative and nonconservative single-degree-of-freedom systems, Non-linear systems with harmonic excitations; Multifrequency excitations; Parametric excitations; Systems having finite degrees of freedom; continuous systems; Traveling waves.</p>		
ME60071	Fatigue, Creep and Fracture	(3-1-0-4)
<p>Fatigue : Types of fatigue loading and failure, Fatigue test, endurance limit; Fatigue under combine stresses; Influence of stress concentration on fatigue strength, Notch Sensitivity, Factors influencing fatigue behaviour.</p> <p>Creep : Creep-stress-time temperature relations, Mechanics of creep – Creep in tension, bending, torsion, creep buckling, Members subjected to creep and combine stresses.</p> <p>Fracture : Basic modes of fracture, Griffith theory of brittle fracture, Irwin's theory of fracture in elastic-plastic materials, Theories of linear elastic fracture mechanics, stress intensity factors, fracture toughness testing.</p>		
ME60072	Dynamics of Rotors	(3-1-0-4)
<p>Rudiments of Rotor Dynamics, rotor dynamic considerations in machinery design, critical speeds and unbalance response. Factors affecting them such as gyroscopic action, internal damping, fluid film bearings. Stability of rotors. Methods for analysis such as Transfer Matrix, bondgraphs, FEM etc. Vibration of discs and blades. Torsional vibration. Balancing of rotors. Concepts of condition monitoring and signature analysis.</p>		
ME60074	Random Vibration Theory	(3-1-0-4)
<p>Introduction to random processes, probability distributions and associated concept, linear time invariant systems excited by stationery random process. Failure due to random vibration vector random process and response of MIO systems to vector random excitations, theory of Kalman Filter. Chapman-Kolmogorov-Smoluchowski equaion, Flokker-Plank equation and it's solution for simple systems, the method of Ito, cumulant-neglect closure of Ito's equations, some simulation studies of systems excited by random signals</p>		
ME60075	Machinery Fault Diagnostics and Signal Processing	(3-1-0-4)
<p>Failures and failure analysis. Fault detection sensors. Data processing and signal analysis. Condition based maintenance principles, Economic. On-line-techniques-vibration, Noise monitoring etc. Off line techniques – NDT, wear debris analysis, Ferrography etc. Fault analysis planning and system availability. Reliability/failure concepts. Application of diagnostic maintenance to specific industrial machinery and plants.</p>		
ME60076	Vibration and Shock Isolation	(3-1-0-4)
<p>Multidegree of freedom system excited by force and motion with two planes of symmetry. Natural frequencies for T.P.S. problems in isolator application. Natural frequencies for T.P.S and O.P.S inclined isolators and decoupling of modes. Velocity shock-elastic and in-elastic impact, effect of snubbing and preloading. Isolation of shock force that causes small and large displacements. Properties of material, design an isolation. Particular application of isolators.</p>		

ME60077	Finite Element Methods in Engineering	(3-1-0-4)
<p>Basic concepts : The standard discrete system, Finite elements of an elastic continuum-displacement approach, Generalization of the finite element concepts-weighted residual and variational approaches. Element types : triangular, rectangular, quadrilateral, sector, curved, isoparametric elements and numerical integration. Automatic mesh generation schemes. Application to structural mechanics problems : plane stress and plane strains, Axisymmetric stress analysis, three dimensional stress analysis, bending of plates. Introduction to the use of FEM in steady state field problems-heat conduction, fluid flow and non-linear material problems, plasticity, creep etc. Computer procedures for Finite element analysis.</p>		
ME60078	Stability of Elastic Systems	(3-1-0-4)
<p>Definition and concepts stability, Stability theorems. linear systems an stability criteria; Classification of systems; Stability of conservative, pseudo-conservative; gyroscopic and circulatory systems; Direct variational methods of stability analysis; Multiple parameter stability theory and its applications.</p>		
ME60079	Engineering Design Optimization	(3-1-0-4)
<p>Basic concepts : Unconstrained and constrained problems. The Kuln-Tucker conditions; Function of one variable; Polynomial approximations, Golden section method. Finding the bounds on the solution, a general strategy for minimizing functions of one variable; Unconstrained functions of n variables : Zero-order, first-order and second-order methods, convergence criteria; constrained functions of n variables: linear programming, Sequential unconstrained minimization techniques, Direct methods; Approximation techniques; Duality; General design applications.</p>		
ME60089	Modeling and Simulation of Dynamic Systems	(3-1-0-4)
<p>Elements of analytical mechanics; classification of constrains, Principles of virtual work, Lagrange;s first equation. Lagrange's second equation. Hamilton's equations. Nonholonomic mechanical system dynamics, Routh and Gibb's equation, Kane dynamics with application to multi body systems like mechanisms and manipulators. Modelling of systems involving continuous medium. Hamilton's principle for continuous medium. Elements of thermo-continuum and theory of constitutive relations. Advanced topics in bond graph moedlling of physical systems : Elements of multi-bond graphs, Thermo-mechanical bond graphs and continuous systems and other systems of typical interest. Introduction to various system simulation software.</p>		
ME60090	Knowledge Based Systems in Engineering	(4-0-0-4)
<ul style="list-style-type: none"> ○ Introduction to expert systems – Definition, Need for expert systems, Methods of developing expert system – offline training/learning & on-line training/learning ○ Tools for developing expert systems – Hard Computing vs. Soft Computing, Fuzzy Set Theory, Fuzzy Logic Controllers (FLC), Neural Network (NN) Controllers – back propagation network, SOM, radial basis function networks, recurrent neural networks etc., Learning/optimisation tools – traditional (direct search and gradient based) and non-traditional (genetic algorithms (GAs), simulated annealing etc.) techniques. Combined techniques of soft computing – GA-FLC, GA-NN, NN-FLC, GA-FLC-NN ○ Some Applications 		

ME60091 Continuum Mechanics and Rheology (3-1-0-4)

Tensors, kinematics of a continuum, stress, Material frame indifference, constitutive equations, linear elastic solids, Newtonian Viscous fluid, Integral formulation of general principles, Incompressible simple fluid.

ME60093 Acoustics and Noise Control (3-1-0-4)

Acoustic signals radiation by machines and sound propagation in air: their characterization, measurement and analysis. Special analysis. Permissible noise limits, noise source identification. Noise measurement practice. Airport noise, traffic noise. Hearing conservation for industrial workers and related standards, noise control technologies.

ME60095	Finite and Boundary Element Methods in Manufacturing	(4-0-0-4)
<ul style="list-style-type: none"> • Introduction to finite element method; discrimination of domain, elastic analysis of 2D bodies using and rod elements and linear triangular elements; 3D tetrahedron element methodology of mesh generation, assembly an solution, formulation using variational analysis and method residue; heat conduction analysis for steady and unsteady case and extension of the method to the analysis of general potential problems; bending of beams and plates; non-linear, curves and isoparametric elements, area coordinates; numerical integration. • Principle of boundary element method; conversion of basic weighted residue statement into boundary integral equation – inverse statement, concept of fundamental solution; application to potential problem in two and three dimensions; type of boundary elements; brief introduction to formulation of problems in elastostatics. • Practice on development of programs and use of software. 		
ME60097	Modern Manufacturing Processes	(4-0-0-4)
<ul style="list-style-type: none"> • Impact erosion. Theory and application of machining by Abrasive Jet, Water Jet, Water abrasive and Abrasive Flow, Ultrasonic processing of materials (machining, welding, cleaning, hardening), total Form Machining and low stress grinding. • Electrochemical processing of materials (surface modification, Machining, forming, polishing, sharpening, honing and turning); Microhole drilling: Electro-stream and Shaped Tube. • Chemical and Thermo-chemical processing (machining, electroless plating and surface modification). • Thermal energy methods of material processing (machining/welding/heat treatment) by Electro-discharge, Laser and Electron beam, Plasma arc and Ion beam. • Physical Vapour and Chemical Vapour Deposition, and Plasma Spraying. • High Energy Rate Forming and Electroforming. • Theory of hybridisation and advantages of evolved processes: ECG, ECDG, RUM, Laser assisted processing etc. and futuristic trends in manufacturing (Micro to nano manufacturing & RPT) 		
ME60104	Composite Materials	(3-1-0-4)
<p>Classification and characterization of composite materials; fibrous, laminated and particulate composites; laminae and laminates; manufacture of laminated fibre – reinforced composite materials. Macromechanical behaviour of laminar; stress-strain relations, engineering constraints for orthotropic materials, stress-strain relations for lamina of arbitrary orientation. Strength and stiffness of an orthotropic lamina; Bi-axial strength theories. Micromechanical behaviour of laminae; Rule of mixtures; Macromechanical behaviour of laminates : Single layered configurations, symmetric laminates, anti-symmetric laminates, known symmetric laminates; Strength of laminates; Interlaminar stresses; Design of laminates. Buckling and vibration of laminated beams, plates and shells.</p>		

ME60106	Manufacture of Plastic Products	(4-0-0-4)
<ul style="list-style-type: none"> • Introduction: polymeric materials, Engineering plastics, Polymer alloys, Selection of plastics, Mechanical properties, Degradation, Wear resistance, Frictional properties, Special properties, Structural features, Expanded plastics, Plastics as packaging material. • Theoretical aspects; Visco-elastic behaviour, Mathematical models for visco-elastic behaviour, Deformation behaviour of plastics, Reinforced plastics. • Analysis of polymer melt flow; Newtonian and non Newtonian fluid flow, Flow in circular section, Flow in rectangular section etc. • Overview and analysis of various plastics forming operations; Extrusion, Injection moulding, Thermo-forming, Calendaring, Compression moulding, Blow moulding, Transfer moulding, Processing of reinforced plastics, Die design for simple components. 		
ME60109	Rapid Prototyping	(4-0-0-4)
<p>Classification of manufacturing processes, Different manufacturing systems, Introduction to rapid prototyping (RP), Need of RP in context of batch production, FMS and CIM and their application, Basic principles of RP, Steps in RP, Process chain in RP in integrated CAD-CAM environment, Advantages of RP, Classification of different RP techniques – based on raw materials, layering technique (2-D or 3-D) and energy sources: Process technology and comparative study of: Stereo-lithography (SL) with photo-polymerisation, SL with liquid thermal polymerisation, Solid foil polymerisation, Selective laser sintering, Selective powder binding, ballistic particle manufacturing – both 2-D and 3-D, Fused deposition modelling, Shape melting, Laminated object manufacturing, Solid ground curing, Repetitive masking and deposition, Beam interference solidification, Holographic interference solidification, Special topic on RP using metallic alloys, Programming in RP, Modelling, Slicing, Internal hatching, Surface skin fills, Support structure.</p>		
ME60110	Mechanical Drives	(3-1-0-4)
<p>Transmission and its requirements. Matching of load and prime mover. Design of transmission elements. Clutches and brakes. Couplings of different types. Uniform and variable speed transmission. Toothed gears : Kinematic requirements of tooth geometry, cycloids and involutes. Involute trigonometry. Various of gears – helical, herringbone, bevel, spiral bevel, skew helical and worm gearing. Programmed motion and intermittent motion. Mechanisms of various types.</p>		
ME60114	Surface Engineered Materials Technology	(4-0-0-4)
<ul style="list-style-type: none"> • Influence of manufacturing processes on various surface properties of an engineering component; scope of surface engineering in augmentation of surface properties • Different processes used in surface engineering – surface coatings and surface modifications, application oriented surface engineering processes – for 3D surface, powder like substrate, internal surface, mass production; surface engineering problems related to substrate characteristics. • Evaluation of engineered properties – control properties, response properties; surface geometry – characterization techniques (conventional and recent trends); coating thickness measurements – laboratory techniques and special techniques for accurate routine thickness measurements; adhesion measurement – conventional methods and recent developments; Measurement of mechanical properties of engineered surface in nano scale; Evaluation of tribological characteristics of engineered surface in macro, micro and nano scale, simulation of actual application environment in tribometer. 		

ME60115	Micro Electro Mechanical Systems (MEMS)	(4-0-0-4)
<p>Introduction, History, Development and need of Micro-Electro-Mechanical Systems. Overview of MEMS technology, Different electro-physical processes used for machining – dealing with MEMS materials; relevant non-conventional processes; IC fabrication processes used for MEMS; MEMS sensors and actuators; Mechanical process techniques and process models for micro-machining; Fabrication processes and design of the process sequences; Agile Prototyping of design and manufacturing processes in micro-machining and computer based design; Reliability and process control of micro manufacturing processes; Introduction and exposure to nano-technology processes and systems.</p>		
ME60118	Computer Graphics and Visualization	(4-0-0-4)
<p>Raster graphics and volume graphics. Video basics. Display devices and interactive devices; 2-D and 3-D graphics primitives. Clipping in 2-D and 3-D; Generation and projection of 3-D wire frame solid models, polygonal models. Space curves and surface models. Intersection of surfaces and blending; hidden line and hidden surface elimination algorithms; Ray-surface intersection and inverse mapping algorithms. Ray tracing for photo realistic rendering. Illumination models. Shading, Transparency, Shadowing and Texture mapping; Representation of colours.</p> <p>Visualization of experimental and simulated data. Surface construction from scattered data, 3-D data arrays and 2-D cross sections. Elevation maps, topological maps, contour maps and intensity maps; fractals for visualization of complex and large data sets. Algebraic stochastic and Geometric fractals. Modeling of natural forms and textures using fractals; Visualization of multi variate relations. Flow visualization and hyper streamlines; Visualization of Meteorological, cosmological, seismic, biological data for scientific decision making.</p> <p>Animation. Modelling issues in dynamic visualization. Behavioural animation; walk through – coordinate transformation and view transformation; virtual reality interfaces. Interactive and immersive systems for Prototyping and visualization; Visualization in concurrent engineering. Interactive multimedia technology and standards for Video-Graphics-Audio integration and tele-video conferencing.</p>		
ME60120	Chaos in Mechanical Systems	(3-1-0 : 4)
<p>Maps and flows; identification of chaotic systems; criteria for chaotic vibration, period doubling, homoclinic orbits, transient chaos and intermittency, overlap criteria ad-hoc theories, Liapunov's exponent; concepts of fractal geometry; fractal dimension; strange attractors; fractal basin boundaries, measurements of fractal dimension.</p>		
ME60122	Friction and Wear in Machinery	(3-1-0 : 4)
<p>Introduction, surfaces : Nature, characterization and effects, Friction : Mechanisms and types, Wear : Nature, mechanism and types, Surface temperatures : Formulation and measurements, Lubrication : Regimes, Hydrodynamic and hydrostatic lubrication, Lubricants : Characterization, types and effects, Experimental methods, Friction and wear of polymers and composites, Methods of improving tribological behaviour, Case studies.</p>		

ME60124	Analysis and Design of Pressure Vessels and Components	(3-1-0 : 4)
<p>Basic principles : Elastic analysis of shells of revolution, membrane solutions, spherical and cylindrical shells, Junctions of shells of different geometry, Limit analysis, Shakedown. Pressure vessel branches : Radial nozzle in spherical shell, stress concentration factors due to combined loadings, design methods to reduce SCF, nonradial nozzles in spherical shells, Junction analysis of radial and non-radial nozzles in cylindrical shells. Pressure vessel ends : different design forms. Flanges : Stress analysis and design methods. Local loading and local attachments : Supports design. Creep and fatigue in thin pressure vessels and its components. Pressure vessel design codes. Thickwall design : monoblock cylinders and spheres, multiplayer constructions. Pre-stressing of thick shells, shrink fit construction, wire and ribbon wound cylinders, Plastic radial expansion – autofretting. Thermal stress, creep and stress rupture; Dynamic and fatigue behaviour. Case studies : Vessels for special purposes. Computer aided design of pressure vessels</p>		
ME60126	Mechanisms and Robot Kinematics	(3-1-0 : 4)
<p>Introduction to Mechanisms, Vector methods in plane kinematics, Matrix Methods in Kinematics, analysis of space mechanisms, Mobility analysis of Mechanisms, Rigid body guidance, uncton Generation, Path generation, Dynamics of Mechanisms, Optimal Synthesis. Introduction to Robot, Manipulator Dynamics and Controls, Computer-Aided Methods for setting and solving Mathematical models of active mechanisms. Methods based on Newton-Euler formulations, Lagrange-Euler formulations, Apple's equations, Kane dynamics and Bond Graphs, Drives and control devices for manipulators, various considerations in control system design for manipulation, current amplification and voltage amplification and compensation techniques. Adaptive controls and model based controls, controls by impedance adjustments, Dynamical methods for the evaluation and choice of industrial manipulator.</p>		
ME60130	Manufacturing Information System	(3-1-0 : 4)
<ul style="list-style-type: none"> • Introduction to Data Processing and Information Systems. Fundamentals of Information Technology. • Data bank concepts. CAD/CAM databases. Data-Bank-Information storage and retrieval. Data life cycle. Desirable characteristics of Data processing systems. Level of decision-making and Information requirements. Data dictionaries in Manufacturing. Integrated Information System. Object Oriented Models. • Structured Query Languages, Implementation of an Information System. • Distributed databases. Information processing systems. Use of computer networks. Elements of Automated Manufacturing Systems. Networks in Manufacturing. Local Area Networks – Architecture and Protocols. Manufacturing Message Specification. Manufacturing Automation Protocol. Network and Protocol implementation. LAN design and performance. Sensor level network. Machine level network. Network performance evaluation. • Multimedia information systems. Management of Multimedia databases. 		

ME60134	Numerical Modelling of Manufacturing Processes	(3-1-0 : 4)
<ul style="list-style-type: none"> • Basic concepts of the standard discrete system. Finite difference (FDM), finite element (FEM) and boundary element methods (BEM) for modeling and analysis of manufacturing processes. • Generalization of FE concepts – weighted residual and variational approaches. Element types – plane triangular, quadrilateral, curved isoparametric elements, 3-dimensional elements, axisymmetric, plate and shell elements. • Automatic mesh generation and data visualization schemes. • Mixed and hybrid finite element analysis: thermal modeling of manufacturing processes like induction hardening, arc welding, cooling of castings, forgings, cutting tools and consequent deduction of cooling rate and metallurgical transformations. Thermo-plastic modeling of forming processes like forging, extrusion and rolling. FE modeling of dynamic and non-linear problems. 		
ME60149	Biomechanics	(3-0-0-3)
<p>Elements of Rheology and principles of continuum mechanics, visco-elasticity, generalized theory of elasticity. Properties and mechanics of soft and hard tissues (bones, cartilage, tendon, ligaments and muscles). Movements of body : anatomical positions, planes and axes, body segmentation, calculation of centre of gravity. Structure of bones, classification of joints and relation to motion; synarthrodial, amphiarthrodial and diarthrodial.</p> <p>Kinematics of human motion, forces and stress of human joints during gait, habitual activities and sports activities. Mechanics of hip knee and other joints, mechanics of spine. Animal joint tribology.</p> <p>Segmental bio-mechanics : Segmental rigid body kinematics and dynamics, inverse dynamics, estimation of joint forces and moments, force shairing, estimation of muscle forces.</p> <p>Design/analysis of artificial joints and fracture fixation prostheses; the bio-mechanical effects of implants on the musculoskeletal system; osteoporosis and fracture - risk prediction of bones; bone remodelling.</p> <p>Constitutive behaviour of hemoglobin, cytoplasm, blood-apparent viscosity, Arterial vs. capillary flow. Reynolds, Stokes and Womersley; laminar, turbulent flow. Pulsatile flow in large arteries.</p>		
ME 60201	Advanced Fluid Mechanics	(3-1-0 4)
<p style="text-align: right;"><i>Prerequisite- ME20601</i></p> <p>Concept of continuum and definition of a fluid. Body and surface forces, stress tensor. Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential. Constitutive equations, derivation of Navier-Stokes equations. Exact solutions of Navier-Stokes equations: plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stokes first and second problem, Hiemenz flow, flow near a rotating disk, flow in convergent-divergent channels. Slow viscous flow: Stokes and Oseen's approximation, theory of hydrodynamic lubrication. Thin-film equations. Boundary layer: derivation, exact solutions, Blasius, Falkner Skan, series solution and numerical solutions. Approximate methods. momentum integral method. Two dimensional and axisymmetric jets. Introduction to Hydrodynamic stability: linear stability of plane Poiseuille flow, Orr-Sommerfeld equation. Description of turbulent flow, velocity correlations, Reynolds stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution. Concepts of closure model, eddy viscosity models of turbulence- zero equation, one equation and two-equation models.</p>		

ME60203	Conduction and Radiation Heat Transfer	(3-0-0 3) Prerequisite - ME30603
<p>Derivation of heat conduction equation. Analytical solutions. Eigen value problems. Solution of heat conduction equation by Laplace transform, Fourier transform and separation of variables techniques. Contact resistance.</p> <p>Transient heat conduction, conduction with moving boundary, solidification and melting. Problems with periodic boundary conditions.</p> <p>Fundamentals of thermal radiation; integral equation for radiative exchange; view factors. Radiative exchange between surfaces: black surfaces, gray, diffuse, partially specular surfaces.</p> <p>Radiative properties of participating media : introduction to gas properties, wide band models, total emissivity, particle properties. Radiative transfer through participating media : gray, plane-parallel slab; approximate methods; non-gray media.</p>		
ME 60204	Computational Fluid Dynamics	(3-0-0 3) Prerequisites- ME20601 and ME60201
<p>A brief overview of the basic conservation equations in heat transfer and fluid flow, classification of partial differential equations and pertinent physical behaviour, parabolic, elliptic and hyperbolic equations, role of characteristics, Common methods of discretisation: an overview of finite difference, finite element and finite volume methods, consistency, stability and convergence. Numerical solutions of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination, LU decomposition, TDMA, Jacobi iteration, Gauss Seidel iteration, necessary and sufficient conditions for convergence, spectral radius of convergence and rate of convergence, gradient search methods: steepest descent method and conjugate gradient method. Strongly implicit and modified strongly implicit methods, use of incomplete LU decomposition as preconditioner for conjugate gradient methods.</p> <p>The Finite Volume Method for Diffusion problems: 1-D steady state diffusion problems, specification of interface diffusivity, source term linearisation, discretisation schemes for transient 1-D diffusion problems, discretisation for multi-dimensional diffusion problems, solution of discretized equations by line-by-line TDMA,</p> <p>Convection-diffusion problems: Central difference scheme and its consequences, upwind scheme, exponential scheme, hybrid scheme, power law scheme, a general strategy for discretisation, concept of false diffusion, QUICK differencing scheme. Solution of incompressible Navier Stokes equations: Stream function-vorticity method, Primitive variable approach-requirement of a staggered grid, pressure-velocity coupling- MAC, SIMPLE, SIMPLEC and SIMPLER algorithm, artificial compressibility method.</p> <p>An introduction to unstructured grid finite volume methods</p> <p>Special topics: Turbulence and its modeling, phase-change problems, interface/free surface tracking methods.</p>		

ME 60205	Computational Methods in Thermal engineering	(3-0-0 3) <i>Prerequisites : ME20601, ME30603</i>
<p>Overview of problems in thermal engineering, classification of PDE. Runge-Kutta method for solution of ODE and application to heat transfer and fluid flow problems. Treatment of asymptotic boundary conditions, two point boundary value problems.</p> <p>Concept of conservative and non-conservative form of equations. General techniques for development of finite difference approximations to conservation equations: Taylor series and control volume approach, explicit and implicit procedures. Concept of consistency, round-off error, truncation error, stability and convergence of FDE. Von Neumann Stability analysis.</p> <p>Direct and iterative techniques for solving a large system of algebraic equations forming sparse, banded symmetric and non-symmetric matrices such as Gauss-Seidel, Thomas algorithm, Factorization Schemes, Stones method, SOR, Conjugate Gradient and its variants. Applications 1D/2D/3D steady-state and transient energy equations with conduction/convection and different boundary conditions.</p> <p>Stream function – vorticity formulation and their solution.</p> <p>Techniques for solution of Navier Stokes equations using primitive variables. Concept of upwind, central difference and hybrid schemes. Pressure velocity coupling. Introduction to SIMPLE type algorithms. Concept of cell Peclet (or cell Reynolds) number and its relation to stability. Application to solution of re-circulating flows.</p>		
ME 60206	Advanced Engineering Thermodynamics	(3-0-0 3) <i>Prerequisites- ME20612</i>
<p>Review of laws of thermodynamics. Energy concepts for closed and open systems. Minimization of entropy generation principle and thermodynamic optimization. Exergy analysis of thermal systems and plants. Thermo-economic applications. Phase transition. Equations of state. Multi-component and multi-phase system. Reactive systems. Kinetic theory of gases. Distribution of molecular velocities and energy, transport properties of gases. Principles of irreversible thermodynamics and applications.</p>		
ME 60207	Environmental Pollution and Abatement	(3-0-0 3)
<p>Historical perspective. Human respiratory system; effects of pollutants on human health. Classification and sources of pollutants. CO, CO₂, O₂, N₂ cycles – sources and sinks. Reactions of pollutants in the atmosphere, and their effects; smokes, smog, fog, acid rain and ozone layer. Global warming and its effects. Regulatory laws and standards. Atmospheric lapse rate, inversions and heat balance.</p> <p>Atmospheric diffusion of pollutants, transport, transformation and deposition.</p> <p>Air sampling and pollutant measurement methods, principles and instruments. Ambient air quality and emission standards. Control principles: removal of gaseous pollutants by absorption, adsorption, chemical reaction and other methods. Selective catalytic reduction of NO_x, Particulate emission control; settling chambers, cyclone separation, wet collectors, fabric filters and electrostatic precipitators. Clean coal technology and shifted emphasis on non-carbon sources of energy.</p>		
ME 60208	Solar Energy Technology	(3-0-0 3)
<p>Current alternate energy sources-thermodynamic view point and conversion methods. Components of solar energy systems, collector performance. Radiation and meteorological data processing, long term conversion factors. System configurations and system performance prediction. Simulations, design methods. System design and optimisation. Solar thermal systems applications to power generation, heating and cooling. Solar passive devices : solar stills, ponds, greenhouse, dryers. Trombe wall, overhangs and winged walls. Wind energy conversion systems. Economics of solar and wind energy systems.</p>		

ME 60209	Nuclear Power Generation And Safety	(3-0-0 3) Prerequisite - ME 40603
<p>Basic concepts of reactor physics, radioactivity. Neutron Scattering. Thermal and fast reactors. Nuclear cross-sections. Neutron flux and reaction rates. Moderator criteria. Reactor core design. Conversion and breeding. Types of reactors. Characteristics of boiling water, pressurized water, pressurized heavy water, gas cooled and liquid metal cooled reactors. Future trends in reactor design and operation. Thermal-hydraulics of reactors. Heavy water management. Containment system for nuclear reactor. Reactor safety radiation shields. Waste management. Indian nuclear power programme.</p>		
ME 60210	Theory of Combustion And Emission	(3-0-0 3) Prerequisite - ME20612
<p>Introductory concepts. Thermodynamics of reacting systems: conservation of mass and energy in a chemical reaction, adiabatic flame temperature, second law aspects of chemical reactions. Essentials of chemical Kinetics: molarity and order of chemical reaction, general equation for rate of reaction, equation of Arrhenius, activation energy. Theories of premixed laminar and turbulent flames; concepts of ignition, flame stabilization, extinction and quenching. Theories of gaseous diffusion flames; droplet and spray combustion: theories of atomization, spray combustion models, spray combustion characteristics and design of burners; mechanism and kinetics of coal combustion; fluidized bed combustion; flames related to industrial applications; Emissions from combustion: constituents and types of emission, mechanisms of hydrocarbon and particulate emissions, theories of soot and NO_x formation. Control of emissions.</p>		
ME 60211	Thermodynamic Optimization, Energy Audit and Economy	(3-0-0 3) Prerequisite - ME20612
<p>First law optimization, availability, Exergy analysis. Second law optimization of thermal systems. Energy audits and conservation programme, elements of energy accounting. Plant energy studies: concepts, resources, procedures and implementation. Energy accounting indices, energy budget and variance analysis- statistical and engineering models. Economic aspects, payback. Analysis: energy intensive industries, low consumption industries, e.g. fabrication shops, renewable energy systems.</p>		
ME 60212	Turbulent Flows	(3-0-0 3) Prerequisite - ME20601
<p>Introduction to stability of laminar flows. Linearized stability analysis using Orr-Sommerfeld equations for inviscid and viscous flows. Stability with flexible compliant boundaries, for free-convection flows and under centrifugal forces. Transition to turbulence. General properties of turbulence: instability and non-linearity, statistical nature, vortex stretching, turbulence scales and cascade, mixing and enhanced diffusivity, energy spectrum. Introduction to mathematical analysis of turbulent flows. The closure problem. Reynolds-averaged Navier-Stokes equations. Equations for Reynolds stresses, turbulence kinetic energy and energy of mean flow- convection, production and dissipation of turbulence, re-distribution, turbulent diffusion. Turbulence modeling. Eddy-viscosity/mixing-length models, application to free shear flows and wall-bounded flows. Two-equation models of turbulence: standard k- and k- model. Turbulent free shear flows. Turbulent wall-bounded flows, Law of the wall, velocity defect law, law of the wake.</p>		

ME 60213	I. C. Engines	(3-0-0 3) Prerequisite - ME20612 and ME30608
<p>Air standard and fuel-air cycle analysis of Otto, Diesel and Limited pressure cycles. Effect of design and operating parameters on cycle efficiency.. Modified fuel-air cycle considering heat losses and valve timing. Engine dynamics and torque analysis. Fuels and combustion in S.I. engines, knocking and fuel rating. Energy balance, volumetric efficiency, measurement of indicated and brake power. Advanced theory of carburation and fuel injection. Cooling of engine and governing of engine. Ignition system ; conventional and electronic. Supercharging. Variable compression ratio engine. Wankel rotary combustion engine. Exhaust emissions, its measurement and control. Euro-norms for emissions. Fault diagnosis of S. I. Engines. Modeling of I.C. Engine combustion.</p>		
ME 60214	Energy Conservation And Waste Heat Recovery	(3-0-0 3)
<p>Patterns of energy use, potential for energy conservation, optimum use of energy resources, total energy approach. Coupled cycles, combined plants and cogeneration systems. Need for energy storage, thermal electrical, magnetic and chemical energy storage systems. Utilization of industrial waster heat; gas-to-liquid and liquid-to-liquid heat recovery systems; Recuperators and regenerators, heat pipes; waster heat boilers; fluidized bed heat recovery; shell and tube heat exchangers. Prime mover exhausts; incineration plants; heat pump systems; thermoelectric devices. Utilization of low grade reject heat from power plants. Thermal insulation; energy economics.</p>		

ME60215 Theory of Abrasive Machining**(3-0-0-3)**

- Introduction – purpose of grinding – basics of grinding – similarity between grinding and machining – identification of process parameters in grinding – various grinding processes – finish grinding – grinding for bulk material removal – creep feed grinding – fast feed grinding.
- Grinding Wheels – specifications – grit materials – grit shape and size – bond – structure – concentration – hardness – super abrasive wheels – monolayer wheels
- Grinding Geometry and Kinematics – contact length – measurement of contact length – grinding path – active grits – measurement of active grits – maximum grit depth of cut for regular as well as irregular wheel topography
- Wheel Conditioning – truing and dressing techniques and parameters – effect of dressing on grinding wheel parameters – dressing of super-abrasive wheels – characterisation of wheel topography
- Grinding Mechanism and Mechanics – grinding chips and their analysis – mechanism of chip formation in grinding – shearing, rubbing and ploughing – other sources of energy consumption in grinding – mechanism in super-abrasive grinding – grinding force and specific energy modelling - effect of parameters on forces and specific energy Temperature in Grinding – Measurement of grinding temperature – Thermal modelling of grinding process – effect of grinding parameters on temperature – effect of temperature of job quality – temperature control techniques – grinding fluids and lubrication
- Surface Integrity – Understanding surface integrity – thermal damages in grinding – burning – oxidation – tempering – residual stresses – effect of residual stresses on job quality – measurement of residual stresses – introduction to X-ray diffractometry – XRD measurement of residual stress – application of Barkhausen Noise Technique in grinding
- Grinding Wheel Wear – measurement techniques – wear mechanisms – grinding chemistry – grinding fluids and lubrication
- Special Topics
 - Cryogenic Grinding
 - Monolayer super-abrasive wheels
 - Ductile Regime Grinding
 - Diamond Turning
 - Creep Feed Grinding
 - High Efficiency Deep Grinding
 - High Speed Grinding
 - ELID Grinding
 - Belt Grinding
 - Loose Abrasive Machining

ME 60216 Compressible Flow**(3-0-0 3)*****Prerequisites - ME20601 and ME20612***

Introductory concepts of compressible Flow, Knudsen number and domain of continuum, speed of sound, compressibility effects, subsonic and supersonic flows, Mach cone. One dimensional isentropic Flow: Governing equations, stagnation conditions, critical conditions, maximum discharge velocity, isentropic relations; Choking. Normal Shock waves, Rankine-Hugoniot jump conditions. Fanno line and Rayleigh line flows. Generalized Quasi-One-Dimensional Flow. Operation of Converging-diverging Nozzles. Moving shock waves and contact discontinuity. Oblique shock. Expansion waves: Prandtl-Meyer flow, Mach waves. Riemann invariants for two-dimensional supersonic irrotational flow. Method of characteristics. One-dimensional unsteady compressible flows: Riemann invariants, expansion fan, waves in a shock tube. Compressible boundary layers.

ME 60217	Steam Engineering	(3-0-0 3) <i>Prerequisites - ME20612 and ME30603</i>
<p>Energy scenario. Overview of steam power plant. Analysis of steam cycles. Feedwater heaters. Deaerator and drain cooler. Optimisation of cycle parameters, reheat and regeneration. Analysis of multifluid coupled cycles. Cogeneration of power and process heat. Combined cycle power generation. Fuels. Combustion mechanisms. Draft systems. Combustion control. Furnaces for burning coal in fluidized beds and in pulverized form. Coal handling installation. Different types of boiler and their specific uses. Boiler mountings and accessories. Feedwater treatment. Boiler maintenance. Circulation theory. Downcomers and rises. Drum and its internals. Economiser, convective and radiant superheaters. Superheat temperature control. Recuperative and regenerative air preheaters. Dust and ash removal systems. Environmental aspects of power generation. Steam nozzles, critical pressure ratio and choked flow, supersaturated flow and Wilson line. Turbine blading, pressure and velocity compounding, reaction blading, reheat factor and condition line, parallel exhausts and casing arrangement, blade stresses. Critical speeds, turning gear. Steam condensers, design, air removal system, tube arrangement. Cooling towers, forced, induced and natural draught, wet and dry types.</p>		
ME 60218	Gas Turbines And Jet Propulsion	(3-0-0 3) <i>Prerequisites - ME20601 and ME20612</i>
<p>Introduction: open cycle, closed cycle, industrial application, future possibilities, shaft power cycle: ideal cycle, practical cycle, closed-cycle gas turbines. gas turbine cycle for aircraft propulsion : turbojet, turbofan, turbo-prop engine, thrust augmentation. Axial flow compressors: elementary theory, degree of reaction, three-dimensional flow, blade design. Axial compressor characteristics. Axial flow turbine: vortex theory, overall turbine performance, the cooled turbine. Prediction of performance of gas turbine.</p>		
ME 60219	Atmospheric Flows	(3-0-0 3) <i>Prerequisite - ME20601</i>
<p>Equations of Geophysical Fluid Dynamics. Geophysical Turbulence modelling. Stratified, Coriolis and buoyancy driven flows. Rossby waves, Acoustic gravity waves. Planetary waves and atmospheric tides. Stratified atmospheric boundary layer near ground. Free convection boundary layers. Boundary layers over terrain. Global circulation models and related computational methods.</p>		
ME 60220	Air-conditioning and Ventilation	(3-0-0 3) <i>Prerequisites - ME20601, ME20612 and ME30603</i>
<p>Introduction - indoor air quality, ventilation, comfort and need of air conditioning. Thermodynamic properties of moist air - Goff and Gratch tables, psychrometric chart and its applications - simple psychrometric processes. Theory of psychrometer and humidity measurement. Comfort indices. Solar time, solar angles, solar radiation and its distribution. Heat Transmission in buildings- overall heat transfer coefficients, solar heat gain factor, Equivalent temperature difference, time lag decrement factor and numerical methods. Calculation of A/c load and supply air state. Duct design methods. Noise level and acoustic control. Automatic control in air conditioning. Design and theory of spray washers. Cooling towers, chilled water and direct expansion coils. Ventilation requirements; mixed, displacement and forced ventilation systems.</p>		

ME 60221	Energy Planning and Management	(3-0-0 3)
		<i>Prerequisite - ME20612</i>
<p>Energy sources. Energy economy interaction. Perspectives on energy modeling. Time series analysis - application to energy modeling. Long range models for global energy demand and supply. Energy planing - national and global policies. Resources depletion and assessment of environmental impacts. Organizing and planning an energy management program. Plant energy studies: concepts and resources, procedures and implementation. Energy accounting. Various thermal systems and energy management. Electrical load management. Economic analysis. Waste heat recovery. Multi objective energy management- conservation, pollution control and evaluation of alternative energy sources. Cost of energy management and payback.</p>		
ME 60222	Hydel Power and Wind Energy	(3-0-0 3)
		<i>Prerequisites - ME20601 and ME20612</i>
<p>Hydel Power: Stream flow data and water power estimates, use of hydrographs; hydraulic turbine, characteristics and part load performance, design of wheels, draft tubes and penstocks, cavitation, plant layouts; costing of water power. Wind Power Engineering: Estimates of wind energy potential, wind maps; aerodynamic and mechanical aspects of wind machine design; wind tunnel simulations, conversion and storage methods; industrial applications. Instrumentation for wind velocity measurements.</p>		
ME 60223	Non-Conventional Sources of Energy	(3-0-0 3)
		<i>Prerequisite - ME20612</i>
<p>Energy scenario and renewable energy sources: global and Indian situation. Potential and economics of non-conventional energy sources. Power generation using renewables. Solar energy: radiation, flat plate and concentrating solar collectors, solar thermal, active systems, solar ponds, passive space conditioning, power generation, solar tower, photovoltaics, space power systems. Principles and applications of wave energy, tidal energy, biomass energy, wind power, geothermal energy and OTEC. Fuel cells: types and technology.</p>		
ME 60224	Heat Exchanger Design	(3-0-0 3)
		<i>Prerequisites - ME20601 and ME30603</i>
<p>Introduction to heat exchangers; types, applications, materials, specification and selection. Review of fluid mechanics and heat transfer, two-phase flow; correlations. Methodology for thermal design of heat exchangers. Rating and sizing problems. Pressure drop calculations. Shell and tube equipment; flow induced vibration; standards: TEMA. Design consideration for plate type devices; regenerators; condensers and boilers; cooling towers and heat pipes. Heat exchanger fouling. Enhancement of heat transfer. Compact heat exchangers. Optimization of heat exchangers; modelling and commercial codes.</p>		

ME 60225	Clean Room Technology/Indoor Environment (3-0-0 3)	Prerequisite - ME30608
<p>Requirements of clean rooms and clean room classifications. Airborne particles - type and size distribution, settling time. Particulate control - external and internal sources, particle identification and control. Air flow pattern control - conventional flow, laminar flow, down flow, cross flow and their effects on particle distribution.</p> <p>Indoor design conditions - process specific and industry specific - Indoor air quality and its control. Human comfort. Psychrometry, thermal load calculation, choice of refrigeration, air-conditioning and pollution control systems. Pollution standards and occupational hazards. Noise generation and control. Case studies.</p>		
ME 60226	Two-Phase Flow (3-0-0 3)	Prerequisites - ME20601 and ME30603
<p>Introduction, different terminologies, flow regimes for single and two component vertical and horizontal flow, flow regime mappings.</p> <p>Conservation equations based on homogeneous flow, drift flux model, separated flow model (multi-fluid model), fluidization, two phase transportation. Critical flow condition. Introduction to Lockhart-Martinelli and other important correlations for pressure drop, correlations for void fraction.</p> <p>Bubbly, slug and annular flow - modelling and experimental validation. Description and classification of boiling. Pool boiling curve. Rohsenow correlation for nucleate boiling. Zuber's theory for critical heat flux. Bromley theory for film boiling. Correlation for flow boiling. Experimental methods for boiling and two phase flow.</p>		
ME 60227	Thermal Systems Design (3-0-0 3)	Prerequisite - ME20612
<p>Design objectives, principle of thermal design; system simulation and optimisation. Modelling of systems. Static and dynamic, stirrer tank models and spatial variation models. Methods of optimization, Lagrange multipliers, search methods, dynamic programming, geometric programming, linear programming. Economic and eco-friendly considerations. Thermodynamic properties, steady state and dynamic behavior of thermal systems. Case studies: Heat Exchangers, Refrigeration systems, Gas turbines, Power plants etc.</p>		
ME 60236	Introduction to Smart Structures (3-0-0-3)	
<p>Smart materials : piezoelectric materials, shape memory alloys, electro-rheological fluids, piezoelectric composites; What is a smart structure? Theoretical modelling of smart structures; active control of smart structures; optimization of placement of sensors and actuators in a smart structure; structural health monitoring.</p>		

ME60303	Robotics	(4-0-0-4)
<ul style="list-style-type: none"> • Introduction to Robotics: Definitions, motivation, historical development, basic structure, classification, workspace, grippers, specifications • Robot Arm Kinematics and Dynamics: Frame transformation, D-H parameters, Forward kinematics, Inverse kinematics, Lagrange formulation • Trajectory Generation: Cartesian scheme, Joint space scheme • Teaching Methods: Manual teaching, Lead-through teaching, VAL programming • Sensing: Range sensing, proximity sensing, touch sensors, force and torque sensing • Robot Vision: Low-level vision, Higher-level vision • Control Schemes: Position control, force control, hybrid position and force control • Motion Planning: Traditional and non-traditional techniques 		
ME60304	Product Development and CIM	(4-0-0-4)
<ul style="list-style-type: none"> • Characteristics and Capabilities of Manufacturing Processes, • Principles of design for manufacturability • Design Cycles, Product Planning, Conceptual Design, Functional and Aesthetic Design, • Case Studies. • Introduction to the Manufacturing Systems, Types of Manufacturing Systems, Manufacturing Automation and Computer Integrated Manufacturing (CIM). • Coding of Components, Group Technology in Manufacturing, Process Planning, Variant approach, Generative approach, Computer Aided Process Planning (CAPP), • Application of Production Flow Analysis in Manufacturing. 		
ME60305	CAD for Manufacturing	(4-0-0-4)
<ul style="list-style-type: none"> • Introduction to CAD/CAM/CAE for manufacturing. Prototyping cycle for product design, manufacture and life management. Competitive design and manufacturing cycles for rapid product realization. CAD tools and industry adoption of standards. • Introduction to geometric modelling. Basic modelling and representation of lines, curves, surfaces and solids. Constructive Solids Geometry. Surface modelling techniques. Solids Modelling. Boundary Representation. Spatial enumerative techniques. Object representation. Object validation. Constraints and feature modelling. Feature based data representation. Object visualization. Texturing. Ray tracing and related algorithms. • Assembly modelling. Feature based analysis. Disassembly analysis. Manufacturing analysis. Dimensioning, Tolerance and fits representation and analysis. Product manufacturing planning. Design Structure matrix. Data extraction for product design analysis. • Elements of primary processes CAD modelling – Casting, Rapid prototyping etc. • Tools for automated generation of cutter path from CAD representation in secondary processes. Rapid Prototyping and machine data generation from CAD models. Elements and data structures for standards based data exchanges – IGES, STEP, STP etc. Web-based product visualization and collaboration. Web based manufacturing planning. • Advanced topics: <ul style="list-style-type: none"> ✓ Surface generation methods – algorithm examples. ✓ Cutter path generation software development. • Development of interaction methods to exchange CAD-CAM data in networked environment. 		

ME60306	Precision and Micro Manufacturing	(4-0-0-4)
<ul style="list-style-type: none"> • INTRODUCTION: basic definition, size scales, scaling analysis, technology change, Lithographic Processes- Optical and X-ray. • PRECISION ENGINEERING AND PRACTICES: Definitions, Sources Of Error, Basic Concepts Of Machining, Machine Tool Variables- accuracy, stiffness, spindle vibration, flatness, straightness, and smoothness of motion, 1-2 DOF systems, Feedback Variables, Cutting Tool Variables, Workpiece Variables, Environment Effects and Thermal Errors. • INTRODUCTION TO MACHINING ANALYSIS: geometry of Cutting Edge, Energy Models, Comparison with Micro-scale Machining. • DIAMOND MICROMACHINING: Introduction, Diamond as a Tool Material, Compatible Materials, Diamond Performance, Diamond Machining, Micro-mechanical Applications, Diamond Machining as a Micro-mechanical Process Research Method, Ductile Regime Grinding MICRO-ECM, MICRO-EDM etc. • MICROMILLING: Micro-milling Tools, Process Results and Micro-milling Applications- micro-mechanically milled X-ray masks, micro-milled mask materials, Mask Absorption Quantification, Exposure Quantification. • MICRODRILLING: Micro-drilling and Macro-drilling Techniques. • LASER MICROMACHINING: laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation. • LIGA, S-LIGA • Micro welding: Micro welding in similar and dissimilar materials; welding processes like ultrasonic, EB, LB; applications. • Micro casting: Casting processes like vacuum, semi-solid state; applications • Processing of Integrated Circuits, Clean rooms, crystal growing and shaping of wafers, Etching, Photo and other lithography techniques, Impurity introduction, Thermal oxidation, CVD, Metallisation etc. IC packaging 		
ME 60307	Refrigeration Systems	(3-0-0 3)
<i>Prerequisites - ME20601, ME20612 and ME30603</i>		
<p>Brief history of refrigeration, refrigerants and environmental issues. Reverse Carnot cycle and standard vapor compression refrigeration cycle - analysis, comparison and Ewing's construction. Compressors - reciprocating, centrifugal and screw type, volumetric efficiency and performance. Performance of single stage refrigeration cycle and its limitations. Multistage, multi evaporator and cascade systems. Properties of refrigerants – primary, secondary and mixtures. Ozone friendly refrigerants, ozone depletion and global warming. Piping design and lubricants Absorption refrigeration system - LiBr-water and aqua-ammonia systems, calculations by h-x diagrams, Platen-Munter's system and solar energy applications. Steam jet refrigeration, vortex tube, thermoelectric refrigeration and gas cycle refrigeration. Air liquifaction cycles. Condensers and evaporators: classifications, condensation and boiling heat transfer correlations, design and performance. Expansion values - capillary tube, AEV, TEV and float value. Refrigeration system simulation: balancing of condensing unit and evaporator.</p>		

MF30602	Robots and Computer-Controlled Machines	(4-0-0: 4) Prerequisites: ME13601, ME30604, ME30605
<p>Drive systems of robots, Electrical and hydraulic systems, AC and DC drives, Servo drives using voltage control, current control and direct torque control, PID control systems and performance issues. Feedback systems. Single loop and multi-loop, DSP based motion control systems, Sensors for industrial robots, encoders, resolvers, hall-effect sensors, acoustic sensors, ultrasonic and optical/infrared sensors, Elements of robot vision, Integration using PLCs. Digital motion planning systems.</p> <p>Introduction, classification, design features and control features of CNC machines; Programming : G & M Code programming, Offline (APT-like) programming; Free form surface machining : Isoparametric, Isoplanar and Isoscallop machining strategies</p>		
MF30604	Non-Traditional Manufacturing Processes	(3-0-0: 3) Prerequisites: ME23601, ME30604
<p>Needs of manufacturing industries and the concept of surface integrity. The role of newer & innovative processes for the solutions</p> <p>Impact erosion and the evaluation for impregnation of foreign bodies. Theory and application of Abrasive Jet, Water Jet, Abrasive Flow, Ultrasonic, Total Form Machining and Low stress Grinding.</p> <p>Theory and applications of Chemical Processing: Chemical Machining, etching of semiconductors, coating and Electroless forming and CVD.</p> <p>Theory and applications of Electrochemical machining and grinding including, Electrochemical sharpening, polishing, honing and deburring, surface treatment, coating and Electroforming.</p> <p>Thermal energy methods of material processing (machining, welding, cladding, alloying and heat-treatment): Electro-discharge, Laser, Electron beam, Plasma arc, Plasma spray, Ion beam and PVD.</p> <p>Hybridization of processes for improving process capability and surface integrity. Explanation of some processes like ECDG, ultrasonic and Laser assisted processing, LIGA & SLIGA etc.;</p> <p>Generic manufacturing and introduction to rapid prototyping.</p>		
MF39602	Non-Traditional Manufacturing + CNC Lab	(0-0-3: 2)
<p>EDM Die Sinking Wire-cut EDM Electro-jet Drilling Ultrasonic machining Pulsed Nd-YAG laser Drilling CW CO2 laser cutting Chemical machining Electroforming CNC turning (G & M Code) {involving linear & circular interpolation} CNC turning (G & M Code) {involving secondary operation} CNC milling (G & M Code) {point to point} CNC milling (G & M Code) { involving linear & circular interpolation} CNC milling (use of parametric programming and three letter codes) 3-D surface machining</p>		
MF40601	Computer Integrated Manufacturing	(3-0-0: 3) Prerequisites : ME30604, MF30602, ME23601, ME30605

<p>Building blocks of automation, Mechanisation of parts handling, Automation of assembly, Application development, Automated Manufacturing systems, Performance measures, Markov and Queuing models & Petrinet models.</p> <p>Various manufacturing systems – batch, mass, group, cellular and flexible manufacturing systems; Robotic welding and flexible welding system; Process planning and CAPP; Production Flow Analysis, Integration of design and manufacturing.</p>		
MF41602	Process Dynamics & Adaptive Control	(3-0-0: 3) Prerequisite : ME40601
<p>State space approach to control systems. State transition equations. Linear Time invariant and nonlinear systems. Controllability and Observability of systems. Pole placement design. Design of control systems. Elements of optimal control. Digital control and time delay control systems. Basic concepts of estimation and identification in automatic control systems. Adaptive control of complex process control systems as in automated machining and welding processes, energy based systems and processes. Nonlinear control and related topics using neuro, fuzzy or genetic algorithms. Case studies and descriptions for automated industrial process control applications inclusive of advanced topics in processes for the high tech industry.</p>		
MF41603	Rapid Prototyping	(3-0-0: 3) Prerequisite : ME30604
<p>Classification of manufacturing processes, Different manufacturing systems, Introduction to rapid prototyping (RP), Need of RP in context of batch production, FMS and CIM and their application, Basic principles of RP, Steps in RP, Process chain in RP in integrated CAD-CAM environment, Advantages of RP, Classification of different RP techniques – based on raw materials, layering technique (2-D or 3-D) and energy sources: Process technology and comparative study of: Stereo-lithography (SL) with photo-polymerisation, SL with liquid thermal polymerisation, Solid foil polymerisation, Selective laser sintering, Selective powder binding, ballistic particle manufacturing – both 2-D and 3-D, Fused deposition modelling, Shape melting, Laminated object manufacturing, Solid ground curing, Repetitive masking and deposition, Beam interference solidification, Holographic interference solidification, Special topic on RP using metallic alloys, Programming in RP, Modelling, Slicing, Internal hatching, Surface skin fills, Support structure.</p>		
MF41604	Metal Casting Technology	(3-0-0: 3) Prerequisite : ME30605
<p>Advanced and precision moulding and casting processes- shell and investment moulding, centrifugal casting, full mould process, die casting, squeeze casting, continuous casting; solidification of castings; typical application of gating and risering principles; melting technology; molten metal treatments for ferrous and non-ferrous alloys; automation in foundry; sand conditioning and reclamation systems; pollution control; energy audit.</p>		
MF41605	Metal Forming and Processing of Plastics	(3-0-0: 3) Prerequisite : ME30605
<p>Fundamentals of metal working, Stresses & strains, Yield criteria, Plasticity & visco-plasticity, Super plasticity, Basic energy equations, Upper bound and lower bound techniques, Analysis of conventional processes, High energy rate forming techniques, Principles of die design, Application of numerical procedure: flow and solid based approaches.</p> <p>Powdered metals and fabrication procedures, Applications, Preparation of powders, Compaction & sintering, Yield criteria and flow rules, Hot and Cold pressing (HIP, CIP),</p>		

<p>Numerical procedures. General properties of engineering plastics, Structural features, Behaviour of reinforced plastics and common fabrication techniques, Common fabrication processes and their analysis (Extrusion, Injection moulding, thermoforming etc.), Flow analysis of polymer melt, Typical defects in plastic components and their prevention.</p>		
MF41606	Technology of Surface Coating	(3-0-0: 3) Prerequisite : ME30604
<ul style="list-style-type: none"> • Influence of manufacturing processes on various surface properties of an engineering component; scope of surface engineering in augmentation of surface properties • Different processes used in surface engineering – surface coatings and surface modifications, application oriented surface engineering processes – for 3D surface, powder like substrate, internal surface, mass production; surface engineering problems related to substrate characteristics. • Evaluation of engineered properties – control properties, response properties; surface geometry – characterization techniques (conventional and recent trends); coating thickness measurements – laboratory techniques and special techniques for accurate routine thickness measurements; adhesion measurement – conventional methods and recent developments; Measurement of mechanical properties of engineered surface in nano scale; Evaluation of tribological characteristics of engineered surface in macro, micro and nano scale, simulation of actual application environment in tribometer. 		
MF41606	Technology of Surface Coating	(3-0-0: 3) Prerequisite : ME30604
<ul style="list-style-type: none"> • Influence of manufacturing processes on various surface properties of an engineering component; scope of surface engineering in augmentation of surface properties • Different processes used in surface engineering – surface coatings and surface modifications, application oriented surface engineering processes – for 3D surface, powder like substrate, internal surface, mass production; surface engineering problems related to substrate characteristics. • Evaluation of engineered properties – control properties, response properties; surface geometry – characterization techniques (conventional and recent trends); coating thickness measurements – laboratory techniques and special techniques for accurate routine thickness measurements; adhesion measurement – conventional methods and recent developments; Measurement of mechanical properties of engineered surface in nano scale; Evaluation of tribological characteristics of engineered surface in macro, micro and nano scale, simulation of actual application environment in tribometer. 		
MF41608	Welding Technology	(3-0-0: 3) Prerequisite: ME30605
<p>Characteristics of welding arc, machine characteristics, their mutual interaction; synergic and pulsed welding techniques; resistance welding-monitoring and control; study and analysis of heat flow, cooling rates, residual stresses and distortion in welding; weldability and microstructure characterization and procedure selection based on it; welding codes; non-destructive inspection; solid phase and high energy density welding processes; special applications.</p>		
MF41610	Non-destructive Evaluation and Imaging	(3-0-0) Prerequisites: ME30604, ME30605

<p>Scope of non-destructive evaluation; Liquid-penetrant and magnetic particle inspection techniques; X-ray and gamma-ray radiography; Ultrasonic inspection:- principle of wave propagation through solids, surface waves, pulse echo technique, A,B,C scan; Eddy current testing; Image sensing through welding arc; Thermal imaging; Image reconstruction; Inspection of typical components:- castings, forgings, welded components, brazed and adhesive bonded assemblies</p>		
MF41612	Quantity Production Methods	(3-0-0: 3) <i>Prerequisites : ME30604, ME30605</i>
<p>Classification of production. Industrial and economical aspects of production in large quantity. Various methods of quantity production of common engineering objects like rods, bars, rails, tubes, threaded objects, gears, bearings, cams, cutting tools etc.. Purpose, design and use of jigs and fixtures. Role of automation in quantity production. Scheduling, tool layout and cam layout for semi-automatic and automatic machine tools. Large quantity production by special purpose and transfer machines. Quantity production of small items like washers, seals, laminates, cups, strong and soft tubes, coins etc. by shearing, forming and embossing in press tools. Industrial methods of manufacturing of pins, needles, wires, rims and similar products. Large scale production of various objects made of polymer, ceramics and composites. Quantity production by processes like spinning, bulging, hydro-forming, magneto-forming and explosion forming. Group technology. Selection of processes, tools and systems and process planning for feasible and economic production. Flexible automation and computer control in manufacturing. Assessment and control of productivity, quality and economy in quantity production.</p>		
MF41614	Machine Tool Engineering	(3-0-0: 3) <i>Prerequisite : ME30604</i>
<p>Major techno-economical aspects of machine tools. Kinematic structure, working principle and application of semi-automatic and automatic lathes, gear teeth cutting machines and copying machines. Design principles of special purpose machine tools. Design of machine tool gear boxes, spindles and beds of machine tools. Slides and guides and selection of bearings for machine tools. Rigidity, system compliance and process capability of machine tools. Machine tool vibration and chatter. Foundation and installation of machine tools. Machine tool inspection, testing and maintenance. Flexible automation and robot application in manufacturing by machine tools. Constructional features, operational characteristics and part programming of flexibly automatic machine tools; CNC machining center and FMS and their advantageous applications.</p>		
MF41616	Laser Applications in Manufacturing	(3-0-0: 3)
<p>Common industrial lasers and their output characteristics: CO₂, Ruby, Nd-glass, Excimer and He-Ne. Overview of Laser Applications: laser application in various fields, advantages and disadvantages, economics. Laser processing fundamentals: beam characteristics, optical components and design of beam delivery systems, absorption characteristics of materials, heat flow theory and metallurgical considerations. Cutting and drilling: process characteristics, material removal modes, development of theoretical models and practical performances. Welding: process mechanisms like keyhole and plasma, development of theoretical models, operating characteristics and process variation. Surface modifications: heat treatment, surface melting, surface alloying and cladding, surface texturing, development of theoretical models, LCVD and LPVD. Working principles of interferometers and elementary holography. Special topics: detection and measurement of radiation.</p>		

MF41618 Engineering Metrology**(3-0-0: 3)*****Prerequisite : ME30604***

Precision and Accuracy; Methods of estimating accuracy and precision; Needs for accuracy and precision; Standards and their evolution; Types of errors in measurements.

Simple Measurement Tools: Rules, calipers, height gauges, micrometers, depth gauges, combination set, dial indicators, slip gauges, sine bars etc.

Limits, Fits and Tolerances, & Gauge Design: Basic concepts in limits, fits and tolerances; Selective assembly; Tolerance grades; ISO system of tolerance; Principles gauge design; Work Shop and Inspection gauges; Gauge Design – Basic design rules for Plug and Ring gauges; Taper Plug Gauges, Taper Ring Gauges; Bore gauge.

Interferometers -Types of light sources and Interferometers, Types of scales and gratings, Optical flats, Use of different interferometers for calibration of height standards etc.

Screw Thread Measurement: Standard thread profiles, Different Thread Elements, Effective diameter, 2 wire and 3 wire methods as applied to standard and non-standard thread profiles, Best wire size, Virtual Effective Diameter

Surface Roughness: Sources of surface irregularities in manufacturing, Different elements of surface roughness, Definition of centre line and related roughness parameters, Measurement Instruments, Profilometers, Analysis of roughness signal in frequency domain, Auto-correlation of surface roughness signals, Use of such analysis in identification of state of health of the manufacturing process

Gear Metrology: Different types of gears, Basic elements of a gear, Involute function, Relations between different gear elements of spur and helical gears, Virtual number of teeth, Use of gear tooth vernier for chordal and constant chordal measurements, Span measurement using Base Tangent Micrometers

Coordinate Measuring Machines: CMMs, Applications, Types, Constructions, Materials used for different elements, Probing, Hard Probing and Soft probing, Construction and Working Principle of Touch Trigger Probe, Alignment, Programming, Types of errors

MF49601	Robotics & CIM Lab	(0-0-3 : 2)
<p>Robot teaching using VAL Manipulation problem of a robot Wheeled Robot Programming and Control Walking Robot Programming and Control Elements of sensors and vision CAD-CAM software based for product development Use of CAD to develop Machining sequences for the product realisation. GTL programming for CNC turning (Computer Aided Part Programming) GTL programming for CNC milling (Computer Aided Part Programming)</p>		
MF69002	Microprocessor Application Lab	(0-0-3 : 2)
<p>Introduction and exposure to various basic control devices used in mechatronics applications. Opamps, Microprocessors, Microcontrollers etc. Experiments on Signal Processing using opamps and other active devices. Experiments on Data Acquisition, Signal Generation and simple control exercises using Microprocessors and Microcontrollers. Exposure to Automation devices - Logic Controllers, DSP and FPGA based systems. Experiments on feedback control systems. Experiments using intelligent software based instrumentation and control like Matlab realtime toolbox, Labview etc. Term Project on specific hardware based experimental setups.</p>		