## ME 104 WORKSHOP PRACTICE

Use of carpenter's tools, Exercise in preparing simple joints, Bench fitting practice, Exercise in marking and fittings, Use of measuring instruments.

Smith's forge, Exercise in bending, Upsetting and swaging.

Familiarizing the students with the following processes:

Soldering and brazing, Welding, Heat treatment, Moulding and casting.

Simple machine shop processes, Such as turning, shaping, Milling and sheet metal work.

## ME 106 STATICS

**Statics of Particles**

Forces in a plane, Equilibrium of a particle, Newton's first law, Free body diagram, Forces in space (rectangular components), Equilibrium of a particle in space.

**Rigid Bodies**

Equivalent systems of forces, Principle of transmissibility, Moment of a force, Couple, Varignon's theorem.

**Equilibrium of Rigid Bodies**

Free-body diagram, Equilibrium in two and three dimensions, Reaction at supports and connections, Equilibrium of two-force and three force bodies.

**Analysis of structures**

Internal forces and Newton's Third Law, Trusses, Simple and space trusses, Methods of joints and sections, Frames and machine analysis.

**Forces in Beams and Cables**

Shear force and bending moment diagrams, Cables with concentrated and distributed loads.

**Friction**

Laws of dry friction, Coefficient of friction and angles of friction, Wedges, Square-threaded screws, Journal and thrust bearings, Belt Friction.

**Distributed Forces**

Centroids and centers of gravity, Areas and lines, Composite plates and wires,
Distributed loads on beams, Forces on submerged surfaces, Center of gravity of a three dimensional body and centroid of a volume.
Second moment of area and moments of inertia, Polar moment of inertia, Radius of gyration, Parallel axis theorem.

**Method of Virtual Work**

Work of a force, Virtual work, Real machines and mechanical efficiency, Potential energy and equilibrium, stability of equilibrium.

## ME 111 ENGINEERING DRAWING

**Basics of Engineering Drawing**

Drawing instruments and sheets; Importance of conventions and standards in engineering drawing

**Engineering Geometry**

Geometrical construction of plane figures, conic sections, cycloidal curves and involute

**Multiview Drawing**
Multiview projection and drawing using first and third angle projection methods

**Development of Surfaces**
Development of prisms, pyramids, cylinders and cones

**Sectional Views**
Sections of solids and machine components

**Pictorial Projections**
Types of pictorial views and drawing isometric view

**Dimensioning and Tolerancing**
Dimensioning techniques, size and geometric tolerance and their symbols, types of fits

**Intersection of Surfaces**
Construction of curves from intersection of solids such as cones, cylinders, prisms and pyramids

**Freehand Sketching of Machine Components**
Sketching of temporary and permanent fasteners like bolts, nuts and rivets, shaft couplings, connecting rod, bearings, pulleys, locking devices; Types of thread

**Assembly and Detail Drawing**
Types of working drawing, construction of views of the assembled objects / components.

**System and Process Flow Diagrams**
Construction of process flow diagrams; symbols for piping, instruments and equipment

## ME 112 THERMODYNAMICS

**Thermodynamic Properties**
Introduction, Working substance, System, Pure substance, PVT surface, Phases, Properties and state, Units, Zeroth law, Processes and cycles, Conservation of mass.

**Energy and its conservation**
Relation of mass and energy, Different forms of energy, Internal energy and enthalpy, Work, Generalized work equation, Flow and non-flow processes, Closed systems, First law of Thermodynamics, Open systems and steady flow, Energy equation for steady flow, System boundaries, Perpetual motion of the first kind.

**Energy and property relations**
Thermodynamic equilibrium, Reversibility, Specific heats and their relationship, Entropy, Second law of Thermodynamic property relation from energy equation, Frictional energy.

**Ideal Gas**
Gas laws, Specific heats of an ideal gas, Dalton's law of partial pressure, Third law of Thermodynamics, Entropy of an ideal gas, Thermodynamic process.

**Thermodynamic Cycles**
Cycle work, Thermal efficiency and heat rate, Carnot cycle, Sterling cycle, Reversed and reversible cycles, Most efficient engine.

**Consequences of the Second Law**
Clausius inequality, Availability and irreversibility, Steady flow system.

**Two-Phase Systems:**
Two phase system of a pure substance, Changes of phase at constant pressure, Steam tables, Superheated steam, Compressed liquid and vapour curves, Phase diagrams, Phase roles, Processes of vapours, Mollier diagram, Rankine cycle, Boilers and anciliary equipment.

**Internal Combustion Engines**
Otto cycle, Diesel cycle, Dual combustion cycle, Four stroke and two stroke engines, Types of fuels.

**Reciprocating Compressors**
Condition for minimum work, Isothermal efficiency, Volumetric efficiency, Multi-stage compression, Energy balance for a two stage machine with intercooler.

## ME 202 SOLID MECHANICS I

**Statically Determinate Frames and Beams**
Types of solid body components, statical determinacy, Shear force and bending moment diagrams; Relationships between loading; Shear force and bending moment.

**Statically Determinate Stress Systems**
Stress; Direct, shear, hydro-static. Complementary shear stresses; Bar and strut / column, stresses in thin ring and rotating cylinder, stresses in thin shells due to pressure or self-weight.

**Stress-Strain Relation**
Deformation; Strain; Elastic stress-strain behavior of Materials; Lateral strain and Poisson's ratio; Thermal stress and strain; General stress-strain relationships.

**Statically Indeterminate Stress Systems**
Interaction of different materials, Interaction of different stiffness components, Restraint of thermal strain; Volume Changes; Constrained materials.

**Bending Stresses**
Simple bending theory; bending relationships; General case of bending; composite Beams; Eccentric end load.

**Bending: Slope and Deflection**
Deflection curve of the neutral axis; Double Integration and Super-position methods.

**Theory of Torsion**
Torsion of thin-walled cylinders; Torsion of solid circular shafts; Hollow shafts, Non-uniform and composite shafts, tapered shafts; Torsion of a thin tube of non-circular section**;** Torsion of thin rectangular Strip.

**Theory of Columns**
Euler's theory of buckling; Eccentricloading of long columns. Behaviour of ideal and real struts. Struts with initial curvature Crinkling; Members subjectedto axial and transverse loading.

## ME 204 FLUID MECHANICS I

**Fluid Properties**

Properties of fluids such as density, viscosity, compressibility, surface tension and capillarity, types of fluids.

**Fluid Statics**

Pressure in a fluid at a point, variation of pressure with depth, Homogeneous fluid, Several fluids of different specific weights, Interconnected vessels, Rigid-body motion of fluid, Hydraulic circuits, Force on plane and curved surfaces, Buoyancy and flotation, Stability of a floating body.

Atmospheric equilibrium, Isothermal state, Adiabatic state, The standard atmosphere.

**Fluid Dynamics**

System and control volume, classification of flows, velocity and acceleration fields, stream lines, path lines, and streak lines, Equation of continuity, Euler's equations of motion, Bernoulli equation, Energy equation, Impulse and momentum, One dimensional viscous flow, Laminar and turbulent flow in pipes and ducts, Pipe flow problems, Flow in open channels.

**Dimensional Analysis**

Buckingham- Pi Theorem, Reynolds' Law of Similitude, geometrical, kinematic and, dynamic similarity and related problems.

**Fluid Measurements**

Measurement of static pressure, Stagnation pressure, flow velocity and flow rate measurement including Venturimeter, orifice meter, nozzle meter

## ME 209 MATERIALS AND METALLURGY

**Introduction**

Importance of Material Science and Engineering, classification of materials, material property charts

**Metallic Materials**

***Crystallography***: Types of crystal structures, atomic packing factor, Miller indices of crystallographic planes and directions

***Imperfections in solids***: Classification of defects, types of point defects and their effects on material properties, dislocations, kinetics of dislocations, dislocation interactions, significance of dislocations on material permanent deformation

***Mechanical properties of materials***: Deformation behavior of materials under tensile and compressive loads, Hardness testing, Testing of materials under impact loading, fundamentals of fracture mechanics, importance of fracture mechanics, material characterization of fracture surfaces, stress distribution around a crack, fatigue testing, S-N curves, creep deformation behavior,
ASTM standards for all mechanical tests

***Diffusion in materials***: Diffusion theory, equilibrium and non-equilibrium diffusion mechanisms, effect of diffusion on material properties

***Heat treatment and phase transformation in materials***: Types of heat treatment processes, effects of heat treatment on material structure and properties, concepts of phases in solids, solubility limit in solid solutions, strengthening mechanisms (solid solution and precipitate strengthening), binary phase diagrams, iron-iron carbide phase diagram, diffusional and non-diffusional phase transformation, kinetics of phase transformation

**Polymers**
Structure, Thermoplastics and Thermosetting Polymers, Copolymers, Polymer Crystals, Defects in Polymers Characteristic, Applications and Processing of Polymers: Mechanical Behavior, Viscoelasticity, Fracture, Strengthening Mechanism, Polymer Types, Polymer Processing

**Ceramics**
Ceramic Structure Imperfections in ceramics, Mechanical Properties
Applications and Processing of Ceramics: Types and Applications, Fabrication and Processing

**Composites**
Introduction, Particle Reinforced Composites, Fiber Reinforced Composites, Processing of Composites, Sandwich Panels

**Environmental Degradation**
Material degradation, corrosion, Stress corrosion cracking, corrosion prevention,

**Advanced Materials**
***Nanomaterials***: Classifications of nanomaterials, nanomaterial properties, synthesis and characterization of nanomaterials, significance and application of nanomaterials

**Advanced high strength steels**: Classification of AHSS, material and mechanical characterization of AHSS, properties and applications of AHSS

## ME 213 DYNAMICS

**Kinematics of Particles**
Rectilinear and curvilinear motion of particles, Rectangular, Tangential, Normal, Radial and transverse components of velocity and acceleration, Motion relative to a frame in translation.

**Kinetics of Particles**
Force, Mass and acceleration, Newton's second law, Dynamic equilibrium, Rectilinear and curvilinear motion, Work and energy, Kinetic energy of a particle, Principle of work and energy, Conservation of energy, Impulse and momentum, Impulsive forces and conservation of momentum, Impact, direct and oblique, Angular momentum of particle and a system of particles, Conservation of angular momentum, Variable systems of particles, Systems gaining or losing mass.

**Kinematics of Rigid Bodies**
Translation, Rotation about fixed axis, General plane motion, Absolute and relative velocity and acceleration.

**Plane Motion of Rigid Bodies**
Forces, Acceleration, Energy and momentum, Conservation of linear and angular momentum.

**Kinetics of Rigid Bodies in Three Dimensions**
Equations of motion of a rigid body about a fixed point, About its mass center or about a fixed axis, Gyroscopic motion.

## ME 214 COMPUTER PROGRAMMING AND APPLICATIONS

Introduction to computer programing, problem-solving techniques using computer programing, algorithms and flow-charts.

Elements of programming language, basic data types, variables and constants, arrays, vectors, matrices, random numbers, arithmetic and logical operators, sequential and conditional execution, repetition and

iterative execution, custom and built-in functions, libraries, elements of string processing, screen and file I/O.

Plotting and other data visualization techniques, sorting and searching data.

Numerical and analytical techniques for solving mechanical engineering problems, use of built-in thermo-physical property functions, system of linear equations, roots of a polynomial equation, interpolation, curve fitting and numerical integration.

Use of a state-of-the-art programing language

## ME 215 INTERNAL COMBUSTION ENGINES

**Basic Engine Types and their Operation**

Four-stroke spark ignition engine, Speed and load control in S.I engine, The Four-stroke compression Ignition Engine, Speed and Load Control in C.I engine, The two-stroke cycle, Supercharging, Wankel rotary engine.

**Testing**

Measurement of engine torque and power, Dynamometer principle, Different types of dynamometers: Measurement of brake and indicated horse power, Mechanical pressure indicators, Use of indicator diagram.

**Combustion**

Combustion Equations, Heat of Combustion, Higher and lower heating values, Adiabatic flame temperature.

**Equilibrium Charts**

Idealized cycles and processes, The diesel cycle, The dual cycle, Regenerative cycles, Brayton cycle.

**Fuels**

The natural fuels, Non-petroleum fuels, Characteristics of S.I and C.I engine fuels, LPG as I.C. engine fuel, Octane and Cetane number, Knock and engine Variable: Autoignition in S.I and C.I engines, Knock and S.I engine, Knock and the C.I engine.

**Exhaust Gas Analysis and Air Pollution**

Air Pollution and the engine, Air pollution and the fuel, Control of exhaust-Gas constituents.

**Fuel Metering- SI Engines**

The Engine requirements, The Elementary carburetor, Elements of complete carburetor, Calculation of Air: Fuel ratio, Gasoline injection system.

**Fuel Metering-CI Engines**

C.I injection systems, C.I engine nozzles.

**Engine Characteristics**

Heat transfer and the engine valve, Timing diagram.

**Lubrication**

Engine-Lubrication systems: Engine performance and lubrication, Lubricants of different kinds.

## ME 216 PRODUCTION ENGINEERING I

**Introduction to Manufacturing**

Types of manufacturing industries, materials used in manufacturing and properties of materials, different processing operation.

**Sand Casting**
Introduction, Sand casting, molding, heating and pouring, solidification and cooling.
Pattern: making, material, types, construction, pattern allowances.
Core: making, types, sand conditioning, testing of sand, molding process, tools and equipment, molding machines, different types of casting, cleaning and finishing of castings, inspection of castings.

Note: Experiments on sand casting will be conducted in the lab.

**Permanent Mold Casting (PMC)**
Introduction, types of PMC, gravity die casting and its types. Pressure die casting, Centrifugal casting and their types. Furnaces used in PMC.

**Metal Forming**
Fundamentals, types, hot, warm and cold working.
**Bulk deformation processes:**
**Rolling;** rolled products, rolling types: flat, shape, thread, gear, ring rolling, and rolling mill configurations.
**Forging;** open die, impression die, press, upset, roll, net shape, isothermal forging and swaging.
**Extrusion;** solid & hollow shapes, direct & indirect, hot & cold, continuous & discrete, impact extrusion, hydrostatic.
**Drawing;** bar, wire, tube drawing and its types tike tube sinking, fixed mandrel, floating plug.
**Other metal forming processes;** roll extrusion, riveting, staking, peening, coining, hubbing, burnishing.

**Sheet metal forming processes;** Shearing operations: slitting, blanking, piercing, cutoff, parting, dinking, slotting, perforating, notching, semi-notching, lancing, nibbling, trimming, shaving, fine blanking. Bending operations: V bending, edge bending, flanging, curling, hemming, seaming. Drawing operations like deep and shallow drawing, embossing.

**Welding Processes**
Classification, Fusion welding and its types such as oxyfuel gas welding and oxygen torch cutting, arc welding (shielded metal, flux cored, gas metal, submerged, gas tungsten, plasma, stud welding, Arc cutting), resistance welding (spot, seam and projection. Heating, pressure, current control and power supply for resistance welding).
Solid state welding and its types including diffusion welding, friction welding and ultrasonic welding.
Other welding processes: Forge, Roll, Friction, Explosion, Thermic, Electron beam, Laser welding and cutting, Brazing and Soldering.

Note: Experiments on welding processes will be conducted in the lab.

**Fabrication of Plastics**
Casting, Blow molding and its types, Compression molding, Transfer molding, Cold molding, Injection molding: injection molding machine, mold design and construction, types of mold, cooling and ejection of mold, Reaction injection molding, Welding of plastics.

## ME 217 ELEMENTS OF MACHINE DYNAMICS & DESIGN

**Machine Dynamics**
Kinematics of Motion; kinetics of Motion; Simple Crank and Cam Mechanisms; Linkages; Types of Links; Structure; Kinematic Pair; Mechanism; Cams

**Principles of Design**
Mechanical properties of Materials; Elasticity; Plasticity; Modulus of Resilience; Modulus of Toughness; Ductility, Brittleness; Endurance limits Hardness; Creep; Stress concentration; Notch Sensitivity; Wear, Theories of Failures including Fatigue failure; Soderberg and Goodman Diagrams; Design Parameters and Operating Conditions; Safety and Reliability in Design

**Introduction to Design of Simple Machine Elements**

**Joints:** Knuckle, Cotter and Universal joints; Threaded and Riveted Fasteners

**Couplings:** Flanged and Muff Coupling, Flexible Coupling, Universal Coupling, Oldham Coupling, Chain Coupling, Gear Coupling, Design of Key and Pins; Fluid Couplings.

**Clutches:** Friction Clutches; Types of Friction Clutches; Design of Single Disc or Plate Clutch, Multiple Disc Clutch, Cone Clutch, Centrifugal Clutch.

**Springs:** Types of Springs, Helical Spring, Terms used in Helical Spring, Stresses in Helical Spring of Circular wire, The Curvature Effect; Deflection in Helical Spring of Circular wore Eccentric loading; Buckling of compression Springs, Energy stored in springs, Springs in Series and Parallel, Concentric spring, Leaf Springs,

**Flexible Mechanical Elements:** Belts, Flat and Round Belt drives, V Belts, Timing Belts, Design of a Belt Conveyor; Chain Drives, Roller Chains; Design of Chains including Drag Chain Conveyor; Apron Feeder,

**Brakes and Dynamometers:** Types of Brakes; Materials of brake lining; Block or Shoe Brake; Simple Band Brake; Differential Band Brake; Band and Block Brake; Internal Expanding Brake; Dynamometer; Type of Dynamometer; Prony Brake Dynamometer

**Turning-Moment Diagrams and Flywheel**

Turning Moment of Steam Engine; Turning Moment of Internal Combustion Engine; Turning Moment of Multi-cylinder Engine; Coefficient of Fluctuation of Energy; Coefficient of Fluctuation of Speed. Flywheel; Energy Stored in a Flywheel; Dimensions of the Flywheel Rim.

Note: Experimental work on stiffness of leaf spring, helical spring, brake & clutch systems, fatigue, and buckling will be conducted in the lab.

## ME 305 MACHINE DESIGN

**Design of Machine Elements**

**Shafts and Columns;** Shaft Types and Materials; Design of Shafts under Normal and Combined Loading; Static, Cyclic and Shock Loads; Torsional stiffness; Critical speeds; Shaft Materials Introduction to Flexible Shafting;Column; Types of End Conditions; Euler's Column Theory; Connecting Rods and Crank Shafts.

**Bearing;** Bearing types and Materials, Friction and Wear, Theory and Application of Lubrication and its Methods; Details design of Journal bearing and Thrust bearings, Rolling Contact Bearings, Bearing life, Bearing Load, Bearing Survival, The Reliability Goal, Selection of Ball and Straight Roller Bearings, Spherical and Tapered roller bearings; Selection of Tapered Roller Bearing.

**Plates and Shells;** Introduction to the Design of Pressure Vessels, Thin and Thick Pressure vessels, Stresses in Thin and Thick Pressure Vessel, Compound Cylinders, Stresses in Compound Cylinders, Design of Plates, ASME Codes, Petro-Chemical piping systems; Design of rings and wheels.

**Gear Design**

General gear theory; Design o the Spur gear;, The Lewis formula, the AGMA Stress Formula, The AGMA Strength Formula, Design of any one of the following types of gears; Helical, Worm, Bevel, gear; Gear Trains.

**Application of Industrial Codes**

Introduction to Industrial Design Codes. Application of at least one Design standards i.e. ASME, BS, ANSI, JIS, DIN, and ISO in the design of Machine Elements and Assemblies.

**Elements of Micro Electro- Mechanical System(MEMS)**
MEMS manufacturing; Lithography, Etching, Micromachining; MEMS Devices; Sensors; Actuators; Springs and Fluid Flow devices.

## ME 306 MECHANICAL VIBRATIONS

**Introduction**
Elements andfundamental features of a vibratory systems; Simple harmonic motion and its vectorial representation; Constraints, Generalized coordinates and degrees of freedom; Vibration analysis; Damped and undamped systems; Resonance; Classification of dynamic Systems and their models,

**Single Degree of Freedom Systems**
Free vibration of an undamped translational system and torsional system; Energy Method; Stability conditions; Free vibration with Viscous, Coulomb and Hysteretic Damping; Forced undamped vibration; Formulation of equation of motion for forced vibration; Harmonically excited vibrations; Forced vibration with damping; Response of damped system under harmonic base excitation and under rotating unbalance.

**General Forcing Conditions and Response**
Periodic forcing function; Fourier series; Harmonic functions; Response under periodic force of irregular form; Transient vibrations.

**Two Degree of Freedom Systems**
Equation of motion for two degrees of freedom system; Free vibration of damped systems; Torsional system with free vibration; Coordinate coupling and principal coordinates; Forced vibration of damped system

**Methods for Finding Natural Frequencies and Mode Shapes**
Dunkerley's equation; Rayleigh method; Holzer method; Rayleigh method; Normalization of mode shapes; Matrix iteration method; Eigen value problems

**Vibrations of Continuous Systems**
Transverse vibration of a string; Longitudinal vibration of beams and rods; Torsional vibration of shafts; Vibrations of a uniform bar with end masses; Free and forced lateral vibrations of simple supported thin beams.

**Vibration Control**
Vibration Nomograph; Single plane balancing; Two-plane balancing; Whirling of shafts; Critical speeds of shaft, Vibration transducer; Vibration pickups; Vibration exciters; Signal analysis; Dynamic testing of machines and structures; Experimental modal analysis; Condition monitoring and diagnosis

## ME 307 PRODUCTION ENGINEERING – II

**Machine Tools**
Machine tools using single point tools, description, functions, operations performed on lathe, shaper, planer, and boring machines.

Machine tools using multiple cutting edge tools, description, functions, and operations performed on drilling, milling, gear cutting, broaching machines, and thread manufacturing.

Machine tools using abrasive wheels, description and functions of various types of grinding machines, wheel dressing and wheel balancing, honing, lapping, and super finishing operations.

**Work Holding Devices**
Basic concept and design of different work holding devices like chuck, vices, jigs and fixtures for lathe, milling, drilling etc.

**Machining Parameters**
Determination of machining time and material removal rate for various machining operations, cutting tools for manufacturing, cutting tool material characteristics, cutting tool materials, tool steels, HSS, sintered carbides, ceramics, tin-coated HSS, diamonds and cubic boron nitrides, tool geometry, tool life, tool wear and machinability, Taylor's tool life model, sharpening and reconditioning of cutting tools, Basic concept and design of jigs and fixtures.

**Non-Traditional Machining Processes**
EDM, ECM, and ultrasonic machining.

**Metrology**
Light waves as standard of length, design and operation of linear measuring instruments, slip and block gauges, length bars, limit gauges, sine bar, reference temperature, limits and fits, hole-basis, shaft basis comparators, mechanical, electrical, pneumatic and optical.
Errors in measurement, sensitivity, accuracy and variation, economics of measurement, measurement of squareness, flatness, straightness, roundness, gear and screw threads, advanced measuring and inspection non-contact measurement, machine tool metrology, alignment tests, level of installation, spindle straightness, flatness and squareness.

**Surface Texture and Measurement**
Roughness and measurement of roughness lay, waviness and flaws, CLA and RMS values, predication and average values of roughness for various manufacturing processes like turning, drilling, milling and grinding.

**Standardization**
Introduction, Interchangeability, assembly, principles, preparation of standards, application of standards in design and manufacturing. Standards organizations.

## ME 312 POWERPLANT ENGINEERING

**Cycles**
Review of mass and energy balances for steady flow devices, Related properties with Mollier Chart and steam tables; Steam turbine cycles including Rankine, Superheat, Reheat; Regenerative Cycle, Open Type Feed Water Heaters (FWH) , Closed Type FWHs with Drains Cascaded Backwards and Pumped Forward; Gas turbine (Brayton) Cycle Power Plants, Compressors, Combustors, Low NOx combustors, Turbines, Efficiency, Intercooling; Combined Cycle Power Plants, Gas engines, diesel power plants

**Combined Heat and Power Systems**
Cogeneration of power and process heat, Back Pressure and Extraction Turbines

**Fluid Flow through Nozzles**
Stagnation properties, critical pressure ratio; convergent and convergent-divergent nozzles (subsonic and supersonic nozzles), Variation of velocity and pressure with area, shock wave

**Steam Turbines**
Impulse and reaction turbines; Pressure Compounding (Rateau Staging), Velocity Compounding (Curtis Staging), Reheat Factor and Condition Line.
Turbine governing and controls

**Steam Generators and Fuels**
Types of boilers and their applications; fire tube boilers; water tube boilers; boiler components including feedwater heater, air preheater, economizer and superheater; boiler operation and safety. Internal and external water treatment methods
Fossil fuels including coal, oil and gas; combustion calculations; environmental pollution.

## ME 313 SOLID MECHANICS – II

**Bending Stress**

Combined bending and direct stresses. Shear stresses in bending, bending and shear stresses in I-section beams. Asymmetrical bending, Shear stress in thin-walled open sections and shear center, General case of bending of a thin walled open section, Bending of initially curved bars, Beams with small radius of curvature.

**Elastic Strain Energy**

Strain energy under direct stress and in pure shear, Strin energy in bending and torsion, Maximum stress due to a suddenly applied load and due to impact, Bending deflection of a beam from an impact, Shear deflection, Theorems of Castigliano and Maxwell's Reciprocal Theorem.

**Statically Indeterminate Beams and Frames**

Double integration method; Superposition method; Virtual work; Compatibility and equilibrium methods

**Stress and Strain Transformations and Relationship**

Two-directional stress systems; Mohr's stress circle, Principal stresses and planes, Combined bending and torsion, Two-directional strain analysis, Normal and shear strain in terms of coordinate and maximum shear strain, Relationship between elastic constants.

**Deformation Symmetrical about an Axis**

Thick-walled cylinders, Compound cylinders, Shrink fit, Rotating disk of uniform thickness

**Theories of Yielding**

Maximum Principal Stress Theory, Maximum principal strain theory, Maximum shear stress theory, Total strain energy theory.

**Thin Plates and Shells**

Deflection of thin Plates, bending of circular plates with symmetrical loading, Plates with uniform loading, solid plate with different loading conditions, Axi-symmetrical thin shells, bending stresses in thin shells.

## ME 314 FLUID MECHANICS - II

**Fluid Kinematics**

Reynolds Transport Theorem (RTT) and its application to conservation of mass, linear momentum and angular momentum, Equation of streamline in differential form, Fluid element kinematics, Vorticity and Circulation, Stokes' theorem, Differential form of continuity equation.

**General Theory of Ideal Fluid Flow**

Stream function, Velocity potential function, Flow net, Plane potential flows, uniform flow, line source & sink, free vortex, Superposition of elementary plane potential flows, doublet, flow past stationary and rotating cylinders.

**Viscous Fluid Flow**

Differential form of linear momentum equation, Euler's equations of motion, Viscous flow of incompressible Newtonian fluids, Stokes' viscosity law for Newtonian fluids, Navier-Stokes equations, steady laminar flow between parallel plates, Couette flow, Hagen-Poiseuille flow, Hydrodynamic lubrication, Reynolds' equation, application to infinitely long & short journal bearings, Lift and drag forces.

**Boundary Layer Theory**
Boundary layer development on a flat plate, Boundary layer thicknesses, Laminar boundary layer exact solution, Momentum integral analysis, Turbulent boundary layer, Boundary layer with pressure gradient, boundary layer separation and control.

**Airfoil Theory**
Airfoil geometry and nomenclature, Symmetric & cambered airfoils, Airfoils of infinite and finite span, Characteristic curves, Lift generation, Magnus effect & Kutta-Joukowski theorem.

**Turbomachines**
Classification, Euler turbine equation, Centrifugal pumps, construction, classification, performance, characteristic curves, NPSH, System curve and operating point, Series and parallel operation of pumps, Hydraulic turbines, analysis of reaction and impulse turbines, Similarity laws for turbomachines, Specific speed.

**Computational Fluid Dynamics**
Fundamentals, discretization of flow field and equations of motion, discretization methods, Finite difference approximations of first and second partial derivatives, Solution of resulting systems of algebraic equations.

Note: Experimental determination of characteristic curves for pumps, and Impulse, Kaplan and Francis turbines will be performed in the lab.

## ME 315 HEAT & MASS TRANSFER

**Conduction**
Steady state conduction; one-dimensional heat transfer analysis, general heat diffusion equation for three dimensional geometries for Cartesian, cylindrical and spherical co-ordinates, multi-layered wall, thermal networks, overall heat transfer coefficient; Thermal analysis with internal heat sources;

Heat transfer from extended surfaces (fins).
Transient conduction, lumped capacitance method.

**Radiation**
Radiation intensity, black body radiation, Planck distribution, spectral emissive power, Wein's Displacement law, Stefan Boltzmann law, band emission, emission from real surfaces, surface characteristics, Kirchoff'slaw

View Factor, radiation exchange between black and real surfaces, radiation network

**Convection**
Basic concepts, momentum and thermal boundary layers; dimensional analysis; theoretical analysis for flat plates; laminar and turbulent flow.

Forced convection with laminar and turbulent flow over flat plates and inside tubes and ducts; empirical correlations.

Free convection; similarity parameter, boundary layer, convective coefficients in plates; empirical correlations.

Heat transfer with phase change, boiling and condensation.

**Heat Exchangers**
Classification and preliminary design of heat exchangers, LMTD and NTU methods.

**Mass Transfer**
Mass transfer operations; mass transfer through diffusion and mass transfer coefficients; empirical correlations; analogy between momentum, heat and mass transfer; simultaneous heat and mass transfer..
.

## ME 403 REFRIGERATION AND AIR CONDITIONING

**Refrigeration cycles**
Reversed Carnot cycle, Vapour-compression and vapour absorption cycles, gas refrigeration cycle, Multiple evaporator and compressor systems.

**Psychrometry**
Use of psychrometric chart, Relative humidity, Humidity ratio, Dry bulb, Wet bulb and Dew point temperatures, Psychrometric processes

**Cooling Load Calculations**
Indoor and outdoor design conditions of air conditioning, heating and cooling load calculation, Air conditioning requirements for comfort and industrial processes, Air distributing systems, Design and sizing of ducts, prevention of noise and vibration.
Introduction to computer software used in Refrigeration and air conditioning

**Refrigeration andAir Conditioning Systems Components**
Compressor, Condenser, Evaporator, Expansion devices, Humidifier, Dehumidifier, Fan, Pump, Blower, grills and registers, cooling tower, Automatic temperature and humidity control systems, Pneumatic, electric and hydraulic systems.

**Refrigerants**
Desirable properties of a refrigerant, Classification of refrigerants and their comparison, designation systems, secondary refrigerants (brine), Defrosting air circulation systems

**Application of Refrigeration**
Domestic refrigerators, Water cooler, Cold storage, Ice making plants, Heat pump and Dairy industries applications

## ME 417 COMPRESSIBLE FLOW AND PROPULSION SYSTEMS

**Review of Elementary Principles**
Governing equations for compressible fluid flow: conservation of mass, momentum and energy

**General Features of Compressible Flow**
Sonic velocity and Mach number, difference between incompressible, subsonic and supersonic flow, propagation of sound waves, equations for perfect gases in terms of Mach number, optical methods of investigation

**One Dimensional Isentropic Flow**
Isentropic flow of a perfect gas, limiting conditions (choking), effect of area change on flow properties, flow in convergent and convergent-divergent nozzles, Hugoniot equation, applications of isentropic flow

**Normal Shock Waves**
Formation of shock waves, Weak and Strong waves, stationary and moving shock waves, working equations for perfect gases, operating characteristics of converging diverging nozzle, supersonic diffusers and pitot tube

**Two Dimensional Supersonic Flows**
Governing equations for oblique shock waves and Prandtl-Meyer flow, Shock Polar, variation of properties across an oblique shock wave, expansion of supersonic flow over successive corners and convex surfaces

**Steady Compressible Flow with Friction**
Fannoline, friction parameter for a constant area duct, limiting conditions, isothermal flow in long ducts

**Compressible Flow with Heat Transfer**
Flow in ducts with heating or cooling, thermal choking due to heating, correlation with shocks

**Applications in Propulsion**
Propulsion applications including rocket nozzles, rocket engine staging, supersonic inlets, and exhaust nozzles for air breathing propulsion systems. Parametric cycle analysis for ramjet, turbojet, turbofan, and turboprop engines

Experimental work on following will be performed in the lab:
Use of wind tunnel; determination of Mach Number, drag coefficients of various objects; comparison of aerodynamic designs; pressure distributions on models.

## ME 419 STRESS ANALYSIS

**Elementary Theory of Elasticity**
Introduction to Vector & Tensors, Stress at a point, 3D Mohr Circle, Stress equation of equilibrium, Laws of stress transformation, Principal Stresses & Max Shear Stress at a point, Displacement & deformation, Strain & displacement relationships, Strain equations of transformations, Principal strains, Generalized Hook's Law & Elastic Constants, Compatibility, Displacement field, Stress & Strain relationships, stress and strain relationships; Airy's stress function both in Cartesian and polar Coordinates

**Non-linear Elasticity:** Hyperelasticity; isotropic hyperelasticity; material and spatial description of hyperelastic deformation; compressible Neo-Hookean material

**Theory of Plasticity and Viscoelasticity**
Yielding of ductile isotopic materials; elastic-perfectly plastic (non-hardening) deformation behavior; classical theories of plasticity; strain hardening; plastic flow rule; elastic-plastic bending of beams; viscoelastic behavior of solids

**Experimental Stress Analysis**
Analytical, Numerical and Experimental approaches of stress analysis, advantages & disadvantages, Methods/techniques of Experimental Stress Analysis, Introduction of Strain measurements, Construction and working of electrical resistance strain gauge, Strain sensitivity of Metallic alloy and strain gauge, Strain gauge circuits with applications, Rosettes and its different configurations

**Introduction to Finite Element Analysis**
Finite element method; direct stiffness method; elemental and global stiffness matrices; boundary conditions; element strain and stress function

Note: Experimental determination of strain measurements, and analysis using FE package will be performed in the lab.

## ME 420 OPERATIONS MANAGEMENT

**Industrial Management & Systems**: Introduction to industrial management and administration, System concept, Functions of Management, Managerial decision making, Models as decision aids.

**Plant Location**: Factors affecting location, Multiplant location, Location analysis, Plant layout, Types of layout, Material handling consideration in layout, Internal and External balancing, product and process layout analysis, Layout comparison.

**Production Planning and Control**: Product design, Pre-production planning, Production control for intermittent and continuous process; MRP (Material Requirements Planning), MRP inputs and outputs, Types of MRP; Job shop scheduling; Machine arrangement problems; Control for maximum profit; Scheduling techniques.

**Quality Control**: Sampling risk and economics of sampling; OC (operating characteristic) curve and sampling plan; Average outgoing quality; Sampling methods; Attribute and variable sampling, Concept of control chart, Process Variability; , R, MR, p, np, c and u charts.

**Methods Analysis**: Process chart; Man-Material flow charts; Work station flow charts; Man-Machine charts. Motion study; Principles of motion economy; Applications, Simo chart.

**Work Measurement**: Stop watch time study procedures, Timing methods, Performance rating, Total normal time, Allowance factors, Continuous production study, Work sampling procedures, Predetermined motion time techniques. Wage incentive plan and job evaluation.

**Inventory Control and Forecasting**: Inventory Control, Functions of Inventory, Economic order quality model, its limitations, Economic lot size, Safety stock, Stock out cost, Inventory systems, Inventory system under uncertainty, Quantity discount; Forecasting; Moving average and weight moving average; Capacity Planning

**Project Management**: CPM (Critical Path Method) & PERT (Project Evaluation and Review Technique).

Experiments on following will be conducted in the lab:
Location selection using Factor Rating Method and Centre of Gravity Method, Process charts, time motion study, control charts, acceptance sampling using MIL STD, EOQ, MS Project, Queueing with Poisson arrivals and exponential service times.

## ME 421 GAS TURBINE

**Ideal Cycles**

Effect of pressure, Temperature, Component efficiency on fuel and air consumption and Power of the simple plant, Inter-cooling, reheat, Heat exchanger cycles, Industrial open and closed plant.

**Gas Turbine Cycles for Aircraft Propulsion**

Turboprop, Turbofan and turbojet engines, Influence of altitude and flight speed on performance.

**Centrifugal Compressors**

Principle of operation, Work done and pressure rise, Compressibility effects, Non-dimensional quantities for plotting compressor characteristics.

**Axial Flow Compressors**

Elementary theory, Degree of reaction, Simple design method, Blade design, Calculation of stage performance, Overall performance, compressibility effect

**Combustion Systems**

Form of combustion system, Some important factors effecting combustion chamber designing, combustion process,
Combustion chamber performance.

**Axial Flow Turbines**
Elementary theory, Vortex theory, Choice of blade profile, pitch and cord, Estimation of stage performance, Overall turbine performance.

**Prediction of Performance of Simple Gas Turbines**
Component Characteristics, Off-design operation of the single shaft gas turbine, Equilibrium running of a gas generator, Off-design operation of free-turbine engine, Jet engine.

Experiments on BHP of Gas Turbine, compressor and turbine efficiencies, and specific fuel consumption will be conducted in the lab.

## ME 422 NUCLEAR POWER

**Nuclear Physics Review**
Nuclear structure, Nuclear stability, Binding energy and mass-energy equivalence, Radioactivity (natural and artificial), Decay rate, Mean-life and half-life, Radioactive equilibrium, Nuclear reactions, Q value, Fission reaction, Elastic and inelastic scattering reactions.

**Reactor Physics**
Neutron reaction, Neutron flux, Cross section for scattering, Absorption and fission, Neutron diffusion Neutron leakage, Solution of diffusion equation for a bare reactor, Albedo and reflector saving, Neutron slowing down, Continuous slowing down model' Lethargy, Slowing down power, Moderation ratio, Fermi age.

**Reactor Theory**
Nuclear chain reactors, Criticality, The four factor formula, One group critical equation, The critical size, Non-leakage probability, Neutron life cycle.

**Reactor Kinetics**
Excess reactivity and reactor-period, Xenon poisoning.

**Types of Nuclear Reactors**
Introduction, Pressurized Water Reactor (PWR), and Primary Loop, Pressurize, Chemical Shim Control
A PWR Power plant, Boiling Water Reactor (BWR), and Load Following Control, Current BWR System
High Temperature Gas-Cooled Reactor (HTGR), Advanced Gas Cooled Reactors (AGR).

**Fast Breeder Reactor and Power plants**
Introduction, Nuclear Reactions, Conversion and breeding, Liquid metal fast breeder reactor (LMFBR)
Plant arrangements, LMFBR, Gas cooled Fast breeder reactor (GCFBR).

**Reactor Materials**
Choice of a moderator, The fuel, The coolant, Nuclear fuels.

**Allied Topics**
Nuclear power economics, Fuel reprocessing, Health hazard due to reactions, Shielding, Nuclear applications for peaceful purposes.

## ME 423 COMPUTER AIDED DESIGN / COMPUTER AIDED MANUFACTURING

**COMPUTER AIDED DESIGN (CAD)**

**Fundamentals of CAD**
Introduction, The design process, Application of computers for design, Creating the manufacturing data base, Benefits of CAD.

**Hardware in CAD**
The design workstation, Graphics terminal, Operator input devices, Plotters and other output devices, The central processing unit, Secondary storage.

**Computer Graphics Software and Data Base**
The software configuration of a graphics system, functions of a graphic package, Constructing the geometry, Data base structure and content, Wire-frame versus solid modeling, other CAD features and CAD/CAM integration.

**Mathematical Elements of CAD**
Two dimensional transformations, Translation, Scaling and rotation, Concatenation, Various techniques for design optimization, finite element analysis / modeling.

**COMPUTER AIDED MANUFACTURING (CAM)**

**Conventional Numerical control**
Introduction, basic components of an NC system, The NC procedure, NC coordinate systems, NC motion control systems, Applications of numerical control, Economics and justification

**NC Part Programming**
Punched tape in NC, tape coding and format, manual part programming, computer assisted part programming, The APT language, NC programming with interactive graphics, Voice NC programming, manual data input, APT word definitions.

**Computer Controls in NC**
Problems with conventional NC, NC controller technology, Computer numerical control, Direct numerical control, Adaptive control machining systems, Trends and new developments in NC.

**Robotics Technology and Applications**
Robot anatomy, Accuracy and repeatability, Robot specifications, End effectors, Characteristics of robot applications, Robot cell design, Types of Robot applications

## ME 424 CLEAN ENERGY TECHNOLOGY

**Generalities**
(a) Energy and utility, planetary energy balance and energy resources, energy utilization and utilization rate, energy and ecology, energy requirements and the population explosion.
(b) Conservation of energy, energy conservation opportunities and management.
(c) Introduction to renewable energy sources: Solar, Wind, Ocean, Geothermal, Biomass including biofuels, Hydrogen coupled with other renewable sources, Hydro power, Thermoelectricity. 5

**Solar Energy**
Nature of solar radiation, insolation, architecture and types of solar collectors, Solar Plant configurations, Introduction to Photovoltaic systems, Application software.

**Wind Energy**
History, availability, data collection, wind turbine configurations and characteristics, principles of aerodynamics, wind turbine analysis and performance calculations, Application software.

**Oceanic Energy**
Types of ocean energy: Wave energy and its conversion, tidal energy, energy from currents, salination energy and the Osmotic engine, various conversion schemes and their relative merits and demerits, thermal energy and ocean thermal energy converters (OTEC).

**Biomass Energy**
Composition of biomass, biomass as fuel, Photosynthesis and renewable energy; production and use of biodiesel and ethanol; Merits and demerits.

**Hydroelectricity**
The resource, Types of hydroelectric plants, Applications, Small scale hydroelectricity, Environmental considerations.

**Hydrogen Technology and Fuel Cells (FC)**
Hydrogen as energy storage medium, Introduction to production and storage of hydrogen, Electrochemical cells, FC reactions, Thermodynamics and performance of FC, FC classification, FC configurations and applications.

**Integration**
Existing energy systems; Questions of availability, Pattern of energy use, Economic options; Long term global energy scenarios.

Experiments on determination of radiation with pyranometers, performance of solar collectors, PV modules, effect of wind velocities on power output, effect of tip speed ratio on performance, and fuel cells will be performed in the lab.

## ME 425 FINITE ELEMENT ANALYSIS

**Introduction**
Introduction to general Numerical Techniques; Basic concepts regarding finite element analysis; Matrix stiffness method; Minimum potential energy formulation; Recent developments.

**Finite element analysis of structural problems**
Finite element modeling, element division and numbering scheme; Basic steps in FEA (Preprocessing, solution, postprocessing); Finite element Analysis of Bar element; Finite element Analysis of Truss; Finite element Analysis of Beam; Finite element Analysis of Frame.

**Variational formulation and approximation**
Governing Differential Equations; Transformation of Differential equation into FE equations; Treatment of boundary conditions (Elimination approach, penalty approach); Variational Formulation of boundary value problem; Methods of weighted residuals (Galerkin, Collocation, least square, subdomain); Rayleigh Ritz Method.

**Isoparametric Formulation**
Interpolation techniques (Triangular, Rectangular); shape functions; Lagrange interpolation function; Analysis of one dimensional problems (Linear, Quadratic, Cubic elements); Analysis of two dimensional elements; Integration on master scale, modeling, mesh generation; Gaussian Quadrature formulae, One point form, two point form.

**Finite element applications and Error analysis**
Convergence of solution; Various measures of errors; FEA application to Heat Transfer problems; FEA application to Fluid Mechanics problems; FEA application to Solid Mechanics problems.

**Plane Elasticity**
Assumptions of plane elasticity; Basic equations; Formulation of Plane stress problems; Explicit expression for Constant strain triangular element stiffness matrix; Finite element solution of a Plane stress problem.

## ME 426 PLANT MAINTENANCE

**Principles And Practices Of Maintenance Planning**

Basic Principles of maintenance planning, Objectives and principles of planned maintenance activity, Importance and benefits of sound maintenance systems, Reliability and Machine availability, MTBF (Mean Time Between Failures), MTTR (Mean Time To Repair), Factors of availability, Maintenance organization, CMMS (Computerized Maintenance Management System)

**Maintenance Policies**: Maintenance categories (Breakdown, Preventive, Predictive), Merits and de-merits of Preventive maintenance and Predictive maintenance, maintenance schedules, RCM (Reliability Centred Maintenance), analysis

**Predictive Maintenance**: Condition monitoring, Economics of condition monitoring, Design of a Predictive Maintenance Programme, Total Plant predictive program, Methods and instruments for Predictive Maintenance (pertaining to Vibration analysis, thermography and relevant techniques)

**Maintenance Methods For Basic Machine Elements**: Shaft alignment, Rotor balancing, Bearings, Couplings, Gears and gear boxes, Compressors, Control valves, Conveyors, Lubrication, Fans, Blowers and Fluidizers, Dust Collectors, Pumps, Steam Traps and related equipment.

**Failure Analysis**: Introduction to Root cause failure analysis, General Analysis Techniques, FMEA (Failure Modes and Effect Analysis), Fault-tree analysis, Cause and effect analysis, Sequence of events analysis, Root Cause Failure Analysis Methodology

Experiments on following will be conducted in the lab:
Overall equipment effectiveness, downtime cost, preventive maintenance, FMEA, runout measurement and misalignment in shafts, vibration amplitude, gears, ultrasonic detection

## ME 428 HEALTH, SAFETY AND ENVIRONMENT

**Safety Management & Hazard Communication**

Understanding safety, hazards and accidents, company policy and management responsibilities, professional certification and societies (NIOSH, NEBOSH, IOSH,OSHA), MSDS (Material Safety Data Sheet)

**Accident Prevention & Control**

Accident causes & their control, recordkeeping and forms, accident cause analysis, safety & health economics, trainings, concept of hazard avoidance (FMEA, Fault Tree Analysis)

**Building & Facilities**

Walking & working surfaces, exits, illumination, sanitation, miscellaneous facilities (scaffolding, elevators, boilers etc.), fire protection

**Ergonomics & Safety**

Facets of Ergonomics, workplace musculoskeletal disorders, ergonomics standards and risk analysis, NIOSH lifting equation.

**Health, Toxic & Environment**

Toxic substances, measures of exposure, detecting contaminants, ventilation, noise and radiation, flammable and explosive materials

**Personal Protective Equipment & First Aid**

Protection need assessment, PPE Training; hearing, eye and face respiratory protection, confined spaces, first aid.

**Process Safety**

Material handling and storage, machine guarding, welding, electrical hazards, construction hazards

**Operations Occupational Safety**

Power plant operations (preventing steam/condensate system accidents), safe operations at chemical plants, offshore drilling hazards. Boiler safety & accidents control.

## ME 429 WATER TREATMENT AND DESALINATION

Water quality criteria for potable water, Composition and constituents of water and wastewater, physical and chemical characteristics, microbiological characteristics, water impurities

Coagulation and Flocculation, types of mixers, Zeta potential, chemical reactions of alum and ferrous and ferric ion, jar test for pH adjustments

Softening processes, chemical dosages based on stoichiometry, ion exchange processes, operation and maintenance of ion exchange systems

Sedimentation, Basin design, Factors affecting sedimentation, Carbon adsorption, activation techniques, adsorption characteristics, Relative velocities and head losses, Granular Filtration, Filter media characteristics

Disinfection methods, Ultraviolet, Ozonation and Chlorination

Membrane Filtration: Reverse Osmosis, Nanofiltration and Ultrafiltration, Membrane fouling, Electrodialysis

Wastewater pretreatment, biological principles for treatment of wastewater, suspended growth bio-systems, Wastewater microbiology, primary, secondary and tertiary treatment processes for sludges

Thermal desalination such as Single Vapor compression systems, Multi-stage flash, Multi-effect systems