19.14 Department of Mechanical and Aerospace Engineering

AE3010 **1.5**
Introduction to Aerospace Vehicles

- History of Aviation
- Pre Wright brothers, up to World War II, post World War II, space age
- Key people in the history of aerospace engineering and their contribution
- Classification of aerospace vehicles and their characteristics
- Civilian aircrafts, military aircrafts, fighters, bombers, reconnaissance
- AWACS, helicopters, gliders, launch vehicles, satellites, UAVs
- Missiles: SAM, AAM, anti-tank, cruise missiles, strategic missiles
- Key aerospace companies in the current scenario
- Future of Aerospace vehicles

AE3020 **3**
Aerodynamics
▷ID1100, ID1140, AE3010

- Inviscid aerodynamics
- Subsonic, transonic, and supersonic airfoil theory
- Wing theory
- Introduction to compressible flow
- Normal and oblique shock waves
- Prandtl-Meyer expansions
- Linearized compressible flow
- Hypersonic aerodynamics
- Computational aerodynamics methods

AE3030 **1.5**
Flight Mechanics

- Introduction to flight instruments and earth's atmosphere
- Characteristics of aerospace vehicles
- Case study of some of the popular aerospace vehicles
- Basic aerodynamics, generation of lift/drag. Airfoils and finite wings. Elements of aircraft performance and atmospheric flight mechanics. Introduction to aircraft design, stability and control.

AE3040 **3**
Aerospace Structures
▷ID1160, ID2020, AE3010

- Basic equations of linear elasticity: Concept of stress and strain, Constitutive behavior of materials, Two-dimensional problems in elasticity.
- Aircraft structures and materials: Basic structural elements in aircraft structure, Loads on the aircraft, Aircraft materials
- Beams and thin walled structures: Three-dimensional beam theory, Torsion of bars with arbitrary cross-section, Bending of thin walled beams, Shear center, Torsion of thin walled beams, Warping of thin walled beams.
- Plates: Kirchhoff plate theory, Bending and buckling of plates
- Introduction to Aeroelasticity: Wing divergence and flutter calculations.

AE3050 **1.5**
Aircraft Propulsion
▷ID1140, AE3010

- Basic one-dimensional flows: isentropic area change, heat addition
- Overall performance characteristics of propellers, ramjets, turbojets, turbofans, rockets
- Performance analysis of inlets, exhaust nozzles, compressors, burners, and turbines

AE3070 **1.5**
Rocket Propulsion
▷ID1140, AE3010

- Rocket flight performance,
- Single-/multi-stage chemical rockets,
- Solid propellants
- Liquid propellants
- Cryogenic engines
- Advanced propulsion concepts

ME1010 **1**
Manufacturing Technology

Introduction to Product Design, Introduction to manufacturing, Evolution of manufacturing. Engineering Materials and their selection, Classification of Manufacturing Processes: Formative Processes (Molding Processes, Deformation Processes), Additive Processes (Joining and Rapid Prototyping Processes), Removal Processes (machining, non-conventional), Introduction to Measurements, Machine Tools and Data Communication, Importance of Integrated Design and Manufacturing.

ME1020 **3**
Engineering Mechanics

Kinematics of particles – Rectilinear motion of particles, curvilinear motion of particles, Kinematics of rigid bodies, Kinetics of particles, system of particles, plan motion of rigid bodies, energy and momentum methods, kinetics of rigid bodies in three dimensions, and introduction to mechanical vibrations.

ME1030 **2**
Dynamics
▷ID1130

Kinematics of particles - Rectilinear motion of particles, curvilinear motion of particles, Kinematics of rigid bodies, Kinetics of particles, system of particles, plan motion of rigid bodies, energy and momentum methods, kinetics of rigid bodies in three dimensions, and introduction to mechanical vibrations.

ME1050 **3**
An Introduction to Mechanical Engineering

An introduction to Mechanical Engineering; Disciplines of mechanical engineering; A quick tour of the broad areas of mechanical engineering: statics, dynamics, kinematics, thermodynamics, mechanical design, material science, computer-aided manufacturing

and metallurgy; Research areas in mechanical engineering

ME1221 **1**
Automation Lab

The objective of this course is to (1) Introduce students to automation systems used in industry such as robot manipulators and Programmable Logic Controllers (PLCs) and (2) Train students to accomplish some of the tasks done by robot manipulators and PLCs using commercially off-the-shelf components. The following is the list of experiments: (1) Elevator control using PLC (2) Conveyor belt control and object categorization using PLC (3) Pick and place tasks using robot manipulator (4) Assembly of parts using robot manipulator (5) Unipolar and bipolar stepper motor actuation using microcontroller board and raspberry pi (6) On/Off temperature control of a chamber using microcontroller board and raspberry pi.

ME2030 **2**
Manufacturing Science -I
▷ME1010

Introduction to Manufacturing and its evolution, Net and near-net shape manufacturing; Metal Casting: Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Product Design; Metal Forming: Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axi-symmetric bulk deformation processes, Analysis of Deep Drawing and Bending, Introduction to High velocity forming processes; Powder Processing (Metals and Ceramics), Polymer Part Manufacturing, Introduction and properties of polymer melts and Visco-elasticity, Processing of Thermoplastics (Extrusion, Injection Molding, Blow Molding, Rotational Molding) and Thermosets (compression and transfer molding), Tool and product design principles; Rapid Manufacturing: Need for RP/RT/RM, Introduction to Processes for Prototyping, Tooling and Manufacturing; Joining and Welding: Introduction, Solid State and Fusion Joining, Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining; Metrology: Tolerancing (Dimensional and Geometric) principles and their measurements (Geometrical tolerances using point data), Interferometry - principles, flatness testing using optical flat, optical interferometers, Moire fringe system measurements.

ME2040 **1.5**
Instrumentation

Introduction to measurements, various principles of measurements, errors in measurement, basic statistics, calibration procedures, displacement measurement, measurement of temperature, measurement of pressure, measurement of fluid flow, obstruction meters, measurement of fluid velocities, thermal anemometry, strain gauges, measurement of force, torque and power, load cells, torque cells, dynamometers, vibration measurement, velocity and acceleration measurement.

ME2050 **2**
Instrumentation

Introduction to measurements, various principles of measurements, errors in measurement, basic statistics, calibration procedures, displacement measurement, measurement of temperature, measurement of pressure, measurement of fluid flow, obstruction meters, measurement of fluid velocities, thermal anemometry, strain gauges, measurement of force, torque and power, load cells, torque cells, dynamometers, vibration measurement, velocity and acceleration measurement.

ME2080 **1**
Introduction to Mathematical Modelling
▷MA1110, MA1220, MA1130, MA1140, MA1150

Introduction to mathematical modelling, introduction to symbolic and numerical computation, degrees of freedom, modelling in dependent and independent coordinates, lagrange equations, and numerical solution of mathematical models.

ME2090 **2**
Kinematics of Mechanisms
▷ID1130, ME1030

None

ME2100 **2**
Dynamics of Mechanisms
▷ID1130, ME1030

Dynamics of rigid body in a plane; static and dynamic force analysis of machines; balancing of rotating masses; balancing of reciprocating masses - single and multi-cylinder engines; turning moment diagram, flywheel analysis; free and forced vibration of single degree of freedom systems - resonance, vibration isolation

ME2110 **3**
Solid Mechanics
▷ME1020

Introduction – Mechanical behaviour of materials, tension, compression and shear stresses, axially loaded members, torsion, beam bending, transverse shear, combined loading, and impact loading. Deflections of beams, energy methods, analysis of stress and strain, stress transformation, applications of plane stress, pressure vessel, column buckling, and statically indeterminate structures.

ME2120 **3**
Thermodynamics

Introduction to thermodynamics. System, surroundings, boundaries, Units and dimensions. Properties of systems. Equilibrium, processes, interactions. The work interaction. Thermodynamic definition of work. Adiabatic systems and processes.

Adiabatic work. The First Law. Basic form. Energy of a system. The heat interaction. Diathermic boundary. Zeroth law. Isothermal states. Gas thermometer. The ideal gas. The state principle. Equations of state. Properties of gases. Properties of steam. Introduction to steam tables. Other equations of state. Critical state. Reduced equation of state. First law for open systems. Special cases. Steady-flow energy equation. The Second Law. Kelvin-Planck and Clausius statements. Carnot theorem. Thermodynamic temperature. Kelvin scale. Carnot engine. Clausius inequality. Definition of entropy. Evaluation of entropy. Principle of increase of entropy. Formulation of second law for closed and open systems. Combined first and second laws. Cycles: Otto, Diesel, Rankine, Brayton, refrigeration; Availability and Exergy. Lost work. Air-Water mixtures, Psychrometric tables, Desert coolers.

ME2220 **3**
Kinematics and Dynamics of Mechanisms
▷ME1020

Basic kinematic concepts, introduction to mechanisms, links, kinematic pairs, kinematic chains, mechanism and inversions, Kennedy's theorem, velocity and acceleration in mechanism, relative velocity methods, instantaneous center of rotation, acceleration diagram, synthesis of planar mechanisms. Cams: synthesis of translating flat-face, translating roller and oscillating roller follower cams. gears: terminology, fundamental law of gearing, involute profile, interference and undercutting, minimum number of teeth, contact ratio, bevel helical, spiral and worm gears, gear trains – simple, compound and epicyclic gear trains; sliding gear boxes and synchronous gear boxes. dynamics of machines: dynamics of rigid bodies in plane motion; dynamic force analysis of machines. Flywheels, balancing of rotors and in-line internal combustion engines, Chain and belt drive.

ME2230 **3**
Manufacturing Science -1

Introduction to Manufacturing and its evolution, Net and near-net shape manufacturing; Metal Casting: Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Product Design; Metal Forming: Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axi-symmetric bulk deformation processes, Analysis of Deep Drawing and Bending, Introduction to High velocity forming processes; Powder Processing (Metals and Ceramics), Polymer Part Manufacturing, Introduction and properties of polymer melts and Visco-elasticity, Processing of Thermoplastics (Extrusion, Injection Molding, Blow Molding, Rotational Molding) and Thermosets (compression and transfer molding), Tool and product design principles; Rapid Manufacturing: Need for RP/RT/RM, Introduction to Processes for Prototyping, Tooling and Manufacturing; Joining and Welding: Introduction, Solid State and Fusion Joining, Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining; Metrology: Tolerancing (Dimensional and Geometric) principles and their measurements (Geometrical tolerances using point data), Interferometry – principles, flatness testing using optical flat, optical interferometers, Moire fringe system measurements.

ME2240 **3**
Fluid Mechanics
▷ME1020

Introduction - scope and relevance; Method of analysis - system vs control volumes - differential vs integral approach, Units and dimensions; Fluid properties - continuum, density, viscosity, surface tension, velocity, pressure, temperature; Fluid Statics - Hydrostatics, Fluid forces on planes and curved surfaces, submerged and floating bodies, Buoyancy and stability, Atmosphere as a fluid; Fluid Concepts - Streamlines, streaklines, pathlines, viscous vs inviscid flows, laminar vs turbulent flows, compressible vs incompressible flows; Engineering bernoulli equation; Control Volume analysis: Basic laws - Mass conservation law, thermodynamic laws, Newton's laws, Angular-Momentum principle; Buckingham Pi-theorem; Similitude and modeling - scaling effects; Flows in a pipes and channels - friction factor, flow measurement devices - Venturi meter, Orifice meter. Differential analysis to fluid flow: Conservation of Mass - Coordinate systems, Kinematics - Translation, Rotation, Deformation, derivation of Governing equations of fluid flows - continuity, Euler equations, Potential flows - Bernoulli equation and applications to external aerodynamics, Navier-Stokes equations, Non-dimensional analysis; Exact solutions of Navier-Stokes equations; Internal flows; External flows - Prandtl's Boundary layer theory - flow over a flat plate, concept of similarity; Approximate methods - von Karman Integral analysis; (Thwaites method); Flow separation; Brief introduction to turbulence - characteristics of turbulence, drag crisis.

ME2421 **1**
Solid Mechanics Lab
▷ME2110

Solid Mechanics: Torsion testing, UTM-tensile testing, thin cylinder behavior, buckling of struts, deflection of beams, spring stiffness, impact testing and hardness testing.

ME2431 **1**

Fluid Mechanics: Measurement of fluid properties: density, specific gravity and viscosity,

Fluid Mechanics Lab

surface tension; Measurement of pressure: Manometers, Bourdon pressure gauge; Measurement of discharge coefficient: Venturi meter, Orifice meter, Rota meter and V/Rectangular notches; Friction loss coefficients in pipe flows: Impact of water jet and stability of floating bodies; channel flow.

ME3010 **2**
Manufacturing Science - II
▷ME2230

Conventional Removal and Finishing Processes: Importance of Material Removal and allied processes, classification; Chip Formation; Types of Chips; Tool Specification: Coordinate and Orthogonal Systems; Mechanics of Metal Cutting: Merchant's Circle Diagram, Stress, Strain and Strain Rate, determination of Shear Plane Angle; Tool Wear and Tool Life; Variables affecting Tool Life; Practical Machining Operations: Turning, drilling, milling; Finishing Operations: Grinding (MRR estimation, Wheel Specifications, Wheel Wear) and other processes; Economics of machining: Minimum Production Cost Criterion, Maximum Production Rate and Maximum Profit Rate Criteria; Unconventional Removal and Finishing Processes: Abrasive Jet Machining, Ultrasonic Machining; Electro Discharge Machining; Abrasive Jet Machining; Electron Beam Machining; Laser Beam Machining, Finishing processes (AFM and other variants); Micro-Manufacturing and Scaling Laws: Miniaturization and its importance, Micro-Manufacturing Processes (Additive, formative and Removal), Scaling laws with emphasis on micro-Manufacturing.

ME3030 **3**
Modeling and Simulation

Introduction to modelling and simulation, introduction to symbolic and numerical computations, degrees of freedom, modelling in dependent and independent coordinates, Lagrange equations, state space formulation, Newton-Raphson method, explicit integrator, implicit integrator, dynamics of constrained mechanical systems as differential algebraic equations, Baumgaurte stabilization, Gauss principle, and inverse problems.

ME3040 **1.5**
Mathematical Elements for Geometrical Modeling

Introduction to computer aided design, fundamentals of computer graphics; geometric modelling of synthetic curves: Hermite, Bezier, B-spline, NURBS. Parametric representation of surfaces: plane, ruled, revolution; Part modelling techniques: wireframe, surface and solid modelling, data representation and exchange formats, geometry and topology. Three-dimensional transformations and projections.

ME3050 **1.5**
Computer Integrated Manufacturing
▷ME3010, ME3040

Current developments in CAD- feature based modeling, design by feature, function, feature linkages, application of feature based models, parametric modeling; Computer Aided Manufacturing: fundamentals of part programming, path generation, post processing and verification; Group Technology, Computer aided process planning (CAPP), computer aided inspection and reverse engineering, manufacturing process simulation, virtual and distributed manufacturing, computer integrated manufacturing.

ME3060 **1**
Experimental Testing Techniques
▷ID1100, ID1160

Basics of statistics. Determining the sample size, hypothesis testing and confidence intervals. Design of experiments, curve fitting and regression analysis, error analysis, practical aspects to documenting, interpreting and reporting experimental data. Data Acquisition and Processing. Data interpretation using graphical tools. Case studies.

ME3070 **1.5**
Power and Refrigeration System

Power and Refrigeration Systems -Gaseous Working Fluids: The Brayton Cycle, The Simple Gas-Turbine Cycle with a Regenerator, Gas-Turbine Power Cycle Configurations, The Air-Standard Refrigeration Cycle, Reciprocating Engine Power Cycles, Combined-Cycle Power and Refrigeration Systems
Gas Mixtures: A Simplified Model of a Mixture Involving Gases and a Vapor, the Energy Equation Applied to Gas-Vapor Mixtures, the Adiabatic Saturation Process, Wet-Bulb and Dry-Bulb Temperatures and the Psychrometric Chart
Thermodynamic Relations: The Clapeyron Equation, Mathematical Relations for a Homogeneous Phase, The Maxwell Relations, Thermodynamic Relations Involving Enthalpy, Internal Energy, and Entropy, Volume Expansivity and Isothermal and Adiabatic Compressibility, Real-Gas Behavior and Equations of State, The Generalized Chart for Changes of Enthalpy at Constant Temperature, The Generalized Chart for Changes of Entropy at Constant Temperature, The Property Relation for Mixtures, Pseudo-pure Substance Models for Real Gas Mixtures, Engineering Applications—Thermodynamic Tables
Chemical Reactions: Fuels, The Combustion Process, Enthalpy of Formation, Energy Analysis of Reacting Systems, Enthalpy and Internal Energy of Combustion; Heat of Reaction, Adiabatic Flame Temperature, The Third Law of Thermodynamics and Absolute Entropy, Second-Law Analysis of Reacting Systems, Fuel Cells, Engineering Applications
Introduction to Phase and Chemical Equilibrium: Requirements for Equilibrium, Equilibrium Between Two Phases of a Pure Substance, Metastable Equilibrium, Chemical Equilibrium, Simultaneous Reactions, Coal Gasification, Ionization, Engineering Applications

ME3080 **2**

Design consideration - limits, fits, tolerances, and standardization, a brief introduction to

Design of Machine Elements
▷ID2020

strength of materials, modes of failure, failure theories, design of springs - helical, compression, tension, torsional and leaf springs, design of joints - threaded fasteners, preloaded bolt joints, welded and glued joints.

ME3090 **2**
Design of Transmission Elements
▷ID2020

Design of shafts under static and fatigue loading, shaft components. Design and analysis of sliding and rolling contact bearings, analysis and applications of power screws and couplings, analysis of clutches and brakes, design of belt and chain drives, design of spur and helical gears.

ME3100 **2**
Modeling and Simulation
▷ME2080

Introduction to modelling and simulation, introduction to symbolic and numerical computations, degrees of freedom, modelling in dependent and independent coordinates, Lagrange equations, state space formulation, Newton-Raphson method, explicit integrator, implicit integrator, dynamics of constrained mechanical systems as differential algebraic equations, Baumgaurte stabilization, Gauss principle, and inverse problems.

ME3110 **3**
Heat and Mass Transfer
▷ME2120, ME2240

Introduction - Steady State heat conduction in one-dimensional systems. One dimensional unsteady state conduction; extended surface heat transfer (Fins). Convection: Basic equations, Dimensional analysis, Boundary layers; Forced convection: External and internal flows, correlations, Natural convection and Mixed convection. Design of heat exchangers: LMTD and NTU methods. Radiation heat transfer: Basic laws, Properties of surfaces, view factors, network method and enclosure analysis for gray-diffuse enclosures containing transparent media. Concepts of Mass transfer. Current trends of research in the field of heat transfer.

ME3140 **3**
IC Engines
▷ME2120

Classification, Basic Working Principles, Components and Engine Operating Events of an IC Engine; Engine Operating Parameters: Geometry, Torque, Power and Work; Fuel Consumption and Efficiencies; Thermochemistry for IC Engines: Fuels and Testing; Combustion Reactions; Combustion Efficiencies; Chemical Kinetics and Exhaust Gas Analysis; Engine Cycle Models: Basic Thermodynamic Analysis; Air Standard Cycles; Fuel-Air Standard Cycles; Comparisons to Real Engines Cycles; Intake Flow Considerations: Gas Flow Processes; Valve Design; Fuel Induction Processes for SI and CI Engines; Combustion Chamber Considerations: In-cylinder Aerodynamics; Burning Process for SI and CI Engines; Abnormal combustion in SI Engines (Knock); Pollutant Formation and Control: Emission Measurement; NOx, CO, Unburned Hydrocarbon, Particulates, formation and their control.

ME3150 **2**
Applied Elasticity
▷ID2020

Introductory tensor analysis, various strain measures and stress tensors, Balance laws, constitutive relations (commonly used energy density functions), special cases through simplification (incompressibility, plane stress and strain, hydrostatic loading, isotropy, linear elasticity), problems in Cartesian and other curvilinear coordinates. Introduction to FEM.

ME3160 **2**
Power and Refregiration System
▷ME2120

Power and Refrigeration System - with Phase Change: Rankine cycle, Effect of pressure temperature on Rankine cycle, Reheat cycles, regenerative cycle, Vapour Compression Refrigeration Cycle, working fluids for vapour compression refrigeration systems, deviation of actual cycles from ideal cycle, the absorption refrigeration cycle. Power and Refrigeration Systems - Gaseous Working Fluids: Air-standard power cycles, Brayton Cycle, Gas turbine power cycles configurations, air standard cycle for Jet propulsion, Otto Cycle, Diesel Cylce, Stirling Cycle, Atkinson and Miller Cycles, Combines Cycle Power and Refrigeration. Gas Mixtures: General considerations of mixture of ideal gases, Mixture model involving gases and vapor, Energy equation applied to gas vapor mixtures, adiabatic saturation process, Wet bulb and dry bulb temperatures and Psychometric chart. Thermodynamic Relations: Clapeyron equation, mathematical relations for homogeneous phase, Maxwell relations, thermodynamic relations involving enthalpy, internal energy, and entropy, property relations for mixtures, pseudopure substance models for real gas mixtures.

ME3170 **3**
Design of Machine Elements
▷ME2110

Design consideration - limits, fits, tolerances, and standardization, a brief introduction to strength of materials, modes of failure, failure theories, design of springs - helical, compression, tension, torsional and leaf springs, design of joints - threaded fasteners, preloaded bolt joints, welded and glued joints. Design of shafts under static and fatigue loading, shaft components. Design and analysis of sliding and rolling contact bearings, analysis and applications of power screws and couplings, analysis of clutches and brakes, design of belt and chain drives, design of spur and helical gears.

ME3180 **3**
FEM and CFD Theory
▷ME2110, ME2240

None

ME3210 **3**

Concept of control, modeling physical systems, Laplace transforms and transfer function,

Control Systems
▷MA2130

block diagrams, Routh's stability criterion, transient and steady state response specification, root locus analysis, lead, lag, and lead-lag compensator design through root locus – P, PI, PD, and PID controllers.

ME3220 **3**
Industrial Engineering and Operations Research

Basics of probability and statistics, Linear Programming and applications, Queuing theory and its applications, forecasting approaches, Monte Carlo simulation procedure (OR). Inventory models discussion (deterministic and probabilistic Models), Newsvendor model, Inventory Planning and Control, Decision support system tools, Economic Order Quantity (EOQ). Product Design: Design for Manufacture and Assembly (DFM), Concurrent engineering Work systems design: Work study and classifications, Method study - work measurement, work sampling, Cost Estimation, Calculation of Machining Times, Cost Depreciation, Productivity, Productivity Measurement, Time study, Recording Techniques for Work Study, Information Collection Techniques, Job Evaluation, Ranking system, Incentive Schemes, Individual-Group-Company-wide Bonus Schemes, Behavioural aspects of Incentives Plant layout, Ergonomics, CRAFT, Cellular Manufacturing, Scheduling, Assembly Line Balancing, Future directions in Production. Quality management and control: Quality Improvement, Cost of Quality, Statistical Process Control, Central Tendency and Dispersion, Control Charts, Acceptance Sampling, New Quality Concepts, Taguchi Methods, Design of Experiments (DoE), Robust Design, Ishikawa Diagram, ISO certification, Kaizen, Zero Defects Program, Total Quality Management (TQM), Six Sigma; Maintenance Management: Preventive and breakdown maintenance approaches, reliability, Work study for Maintenance, Total Productive Maintenance (TPM), Spare Parts Management, Characteristics and classification of Spare parts; Supply Chain design, scheduling, layout design: Materials Requirement Planning (MRP), MRP-II, Enterprise Resource Planning (ERP), Logistic, Distribution and Supply chain Management, Applications of Newsvendor model in supply chains.

ME3413 **2**
Machine Drawing and Solid Modelling
▷ID1041, ID1054

Principle of drawing. Introduction to machine drawing, production drawing, assembly drawing. Different sectional views. Fits, limits, tolerances and surface finish. Solid modelling of different machine elements. Example, threads, bolts, and nuts, welded and riveted joints, shafts, keys, cotter, and pin joints; couplings and clutches, springs, belts, and pulleys; bearings, gears. Assembly of different components of IC engine.

ME3425 **3**
Mini-project

Objective: To direct students toward the process of designing and development through visualization, planning and manufacturing of a product leading to 'Invention and Innovation'. Deliverables: Visualize, Draw, Build, Improve, Modify, Identify, Suggest. Constituents: Concept, Design (Mechanical, thermal, chemical), Drawing (2D/3D manufacturing details), Manufacturing, Testing, Simulation.(NOTE: This is 3-credits for 2016-19 batches and 1-credit for 2020+ batches)

ME3445 **1**
Finite Element Methods Lab
▷ME2110

Finite element methods for solving boundary value problems in solid mechanics. Introduction, Spatial Modelling, Geometric discretization, Element Library, Material Modelling, Loading and Boundary Conditions, Constraints, Surface/Interfaces modelling, Step and job handling and Post-processing. FEA Implementation and Visualization of 1D Problems, Truss Problem, Beam bending, Plane and axisymmetric Problems and 3D problems. Various analysis such as, Static, Transient, Harmonic, Modal, Dynamics and Multi Physics (Thermomechanical, etc).

ME3455 **1**
Computational Fluid Dynamics Lab
▷ME2240

CFD mesh generation techniques, CFD experiments using commercial code - boundary layer flow, convective heat transfer, turbulent mixing and heat transfer, at least one analysis on an advanced topic like multiphase flow, combustion, turbo-machines.

ME3465 **1**
Manufacturing Lab

Job preparation using CNC machining, Robotic welding, 3D printing, EDM, Injection molding. Measurements of parts using CMM; Form measurement; Digitization using 3D scanner, surface roughness testing. Deep drawing using forming machine. Cutting force measurement using dynamometer. Sample preparation and characterization using Optical Microscope.

ME3475 **1**
IC Engines Lab
▷ME3140

Objective: Experimental exposure to testing performance of IC engines at varying operating conditions.
Experiment list: Components of an IC engine - CI and SI types; Testing and performance of IC engines by varying speed, load, compression ratio and other parameters. Study of Valve Timing Diagram.

ME4010 **1.5**
Control Systems
▷MA2130

Concept of control, modeling physical systems, Laplace transforms and transfer function, block diagrams, Routh's stability criterion, transient and steady state response specification, root locus analysis, lead, lag, and lead-lag compensator design through root locus - P, PI, PD, and PID controllers.

ME4020 **3**
Turbo Machines
▷ME2120
Axial and radial flow turbomachines; Basic Principles; Dimensional Analysis; Two-dimensional cascades; Axial flow turbines; Axial flow compressors and ducted fans; Centrifugal pumps, Fans, compressors; Radial flow gas turbines; Hydraulic turbines.

ME4030 **1**
Operations Research
Basics of probability and statistics, Linear Programming and applications, Queuing theory and its applications, forecasting approaches, Monte Carlo simulation procedure (OR). Inventory models discussion (deterministic and probabilistic Models), Newsvendor model, Inventory Planning and Control, Decision support system tools, Economic Order Quantity (EOQ).

ME4040 **1**
Industrial Engineering
Product Design: Design for Manufacture and Assembly (DFM), Concurrent engineering Work systems design: Work study and classifications, Method study - work measurement, work sampling, Cost Estimation, Calculation of Machining Times, Cost Depreciation, Productivity, Productivity Measurement, Time study, Recording Techniques for Work Study, Information Collection Techniques, Job Evaluation, Ranking system, Incentive Schemes, Individual-Group-Company-wide Bonus Schemes, Behavioural aspects of Incentives Plant layout, Ergonomics, CRAFT, Cellular Manufacturing, Scheduling, Assembly Line Balancing, Future directions in Production.

ME4050 **1**
Production Planning and Control
Quality management and control: Quality Improvement, Cost of Quality, Statistical Process Control, Central Tendency and Dispersion, Control Charts, Acceptance Sampling, New Quality Concepts, Taguchi Methods, Design of Experiments (DoE), Robust Design, Ishikawa Diagram, ISO certification, Kaizen, Zero Defects Program, Total Quality Management (TQM), Six Sigma; Maintenance Management: Preventive and breakdown maintenance approaches, reliability, Work study for Maintenance, Total Productive Maintenance (TPM), Spare Parts Management, Characteristics and classification of Spare parts; Supply Chain design, scheduling, layout design: Materials Requirement Planning (MRP), MRP-II, Enterprise Resource Planning (ERP), Logistic, Distribution and Supply chain Management, Applications of Newsvendor model in supply chains.

ME4325 **3**
Elective Project
Optional elective project for seventh semester Btech students

ME4435 **1**
Dynamics Lab
Gear Efficiency Measurement, Planar Mechanism Demonstration, Rotary Balancing, Reciprocating Balancing, Static and Dynamic Analysis of Cam, Whirling of Shaft, Governors, Moment of Inertia Measurement.

ME4445 **1**
Heat Transfer Lab
▷ME3110
Heat Transfer: Temperature measurement and calibration; Measurement of thermal conductivity: solids and liquids; Heat exchangers: Concentric tube, shell and tube; Measurement of convective heat transfer coefficient: Free and Forced convection; Measurement of emissivity; Pool boiling and Condensation.

ME5935 **5**
Dual Degree Thesis (stage-1)
Dual Degree Thesis (Stage-1) for Dual Degree (BTech + MTech) students

ME5945 **18**
Dual Degree Thesis (stage-2)
Dual Degree Thesis (Stage-2) for Dual Degree (BTech + MTech) students

ME5955 **22**
Dual Degree Thesis (stage-3)
Dual Degree Thesis (Stage-3) for Dual Degree (BTech + MTech) students

19.15 Department of Materials Science and Metallurgical Engineering

MS1010 **1**
Science and Engineering of Materials
Introduction to general concepts of metallurgy and materials science and general considerations in application orientated material design - through three example case studies on bone, sensors, and defence materials, Types of materials (metals, ceramics, polymers, hybrids), general material properties (structural and functional), trade off in material properties and brief introduction to optimisation, followed by classroom discussion sessions. Overall, the course offers a wide vision on how materials have led to technological advancement in all aspects and is designed to help appreciate the courses in following semesters.

MS1020 **1**
Metallic Materials
Structure of metals, Determination of structure and chemical composition, concepts of alloys, phase and phase diagrams