Curriculum for Dual Degree Programme
B.Tech. (Mechanical Engineering) - M.Tech. (Thermal Science and Engineering)

Subject Name	Subject Code	L-T-P	Credit	Contact Hour
SEMESTER - I				
Mathematics – I	**MA1L001**	3-1-0	4	4
Physics / Chemistry	**PH1L001 / CY1L001**	3-1-0	4	4
Mechanics / English for Communications or Learning English	**ME1L001 / HS1L001 or HS1L002**	3-1-0/3-0-2 or 3-1-0	4	4/5 or 4
Electrical Technology / Introduction to Programing and Data Structures	**EE1L001 / CS1L001**	3-1-0	4	4
Introduction to Manufacturing Processes / Engineering Drawing and Graphics	**ME1P001 / CE1P001**	0-0-3/1-0-3	2/3	3/4
Physics Laboratory / Chemistry Laboratory	**PH1P001 / CY1P001**	0-0-3	2	3
Electrical Technology Laboratory / Introduction to Programing and Data Structures Laboratory	**EE1P001 / CS1P001**	0-0-3	2	3
EAA	**ID1T001**	0-0-3	1	3
		Total	**22/23+1**	**25/27 or 26+3**
SEMESTER – II				
Mathematics – II	**MA1L002**	3-1-0	4	4
Chemistry / Physics	**CY1L001 / PH1L001**	3-1-0	4	4
English for Communication or Learning English / Mechanics	**HS1L001 or HS1L002 / ME1L001**	3-0-2 or 3-1-0/3-1-0	4	5 or 4/4
Introduction to Programing and Data Structures / Electrical Technology	**CS1L001 / EE1L001**	3-1-0	4	4
Chemistry Laboratory / Physics Laboratory	**CY1P001 / PH1P001**	0-0-3	2	3
Introduction to Programing and Data Structures Laboratory / Electrical Technology Laboratory	**CS1P001 / EE1P001**	0-0-3	2	3
Engineering Drawing and Graphics / Introduction to Manufacturing Processes	**CE1P001 / ME1P001**	1-0-3/0-0-3	3/2	4/3
EAA – 2	**ID1T002**	0-0-3	1	3
		Total	**23/22+1**	**27 or 26/25 +3**
SEMESTER - III				
Theory of Machines – I	**ME2L001**	3-1-0	4	4

Subject Name	Subject Code	L-T-P	Credit	Contact Hour
Basic Electronics	**EC2L005**	3-1-0	4	4
Transform Calculus ***(Mathematics – V)***	**MA2L005**	3-0-0	3	3
Introduction to Material Science and Engineering	**ID2L001**	2-0-0	2	2
Introduction to Bioscience and Technology	**ID2L002**	2-0-0	2	2
Fluid Mechanics	**ME2L002**	3-1-0	4	4
Workshop Processes	**ME2P001**	0-0-3	2	3
Basic Electronics Laboratory	**EC2P005**	0-0-3	2	3
Fluid Mechanics Laboratory	**ME2P002**	0-0-3	2	3
Project Seminar	**ME2S001**	0-0-0	2	0
		Total	**27**	**28**
SEMESTER – IV				
Thermodynamics	**ME2L003**	3-0-0	3	3
Partial Differential Equations ***(Mathematics – IV)***	**MA2L004**	3-1-0	4	4
Environmental Science, Technology and Management	ID2L003	2-0-0	2	2
Breadth-1		3-1/0-0	3/4	3/4
Mechanics of Solids	**ME2L004**	3-1-0	4	4
Theory of Machines – II	**ME2L005**	3-1-0	4	4
Lateral – 1			3/4	3/4
Machines & Mechanisms Laboratory	**ME2P003**	0-0-3	2	3
Materials Testing Laboratory	**ME2P004**	0-0-3	2	3
		Total	**27/29**	**29/31**
SEMESTER – V				
Lateral Theory-2		3-0-0	3	3
Heat Transfer	**ME3L001**	3-1-0	4	4
Design of Machine Elements	**ME3L002**	3-0-0	3	3
Casting, Welding and Forming	**ME3L003**	3-0-0	3	3
Systems & Control	**ME3L004**	3-0-0	3	3
Thermo-Fluid Lab – 1	**ME3P001**	0-0-3	2	3
Casting, Welding and Forming Laboratory	**ME3P002**	0-0-3	2	3
Machine Design Practice	**ME3P003**	0-0-3	2	3
		Total	**22**	**25**
SEMESTER - VI				
Lateral Theory-3	**ME3LXXX**	3-0-0	3	3
IC Engines	**ME3L005**	3-0-0	3	3
Refrigeration & Air-Conditioning	**ME3L006**	3-0-0	3	3
Elective-1	**ME3LXXX**	3-0-0	3	3
Machine Tool & Machining (MTM)	**ME3L007**	3-0-0	3	3
Power Plant Engineering	**ME3L008**	3-0-0	3	3
Thermo-Fluid Lab – 2	**ME3P004**	0-0-3	2	3
MTM Laboratory	**ME3P005**	0-0-3	2	3

Subject Name	Subject Code	L-T-P	Credit	Contact Hour
		Total	**22**	**24**
INDUSTRIAL SUMMER TRAINING				
SEMESTER - VII				
Advanced Fluid Dynamics	**ME6L101**	3-1-0	4	4
Computational Methods in Thermal & Fluid Engineering	**ME6L102**	3-1-0	4	4
Elective – 2	**ME4LXXX/ ME6LXXX**	3-0-3	5	6
Breadth – 2		3-0-0	3	3
Industrial Training Defense	**ME4T001**	0-0-0	2	3
Project – Part 1	**ME4D001**	0-0-0	4	0
Advanced Thermo-Fluids Lab	**ME6L101**	0-0-3	2	3
		Total	**24**	**23**
SEMESTER - VIII				
Advanced Heat Transfer	**ME6L151**	3-1-0	4	4
Elective – 3	**ME6LXXX**	3-1/0-0	4/3	4/3
Breadth – 3		3-0-0	3	3
Breadth – 4		3-0-0	3	3
Project – Part 2	**ME4D002**	0-0-0	6	0
Thermo-Fluids System Simulation Lab	**ME6L102**	0-0-3	2	3
		Total	**22/21**	**17/16**
SEMESTER - IX				
Elective – 4	**ME6LXXX**	3-0/1-0	3/4	3/4
Seminar	**ME6S101**	0-0-0	2	0
Thesis-Part 1	**ME4D001**	0-0-0	12	0
		Total	**17/18**	**3/4**
SEMESTER - X				
Elective – 5	**ME6LXXX**	3-0-0	3	3
Thesis-Part 2	**ME4D002**	0-0-0	13	0
		Total	**16**	**3**
		G. Total	**221/225**	**202/207**

Elective Courses B.Tech. – M. Tech Dual Degree (Thermal Science & Engineering)

Subject Name	Code	L-T-P	Credit	Contact Hour
Elective – I (Semester VI)				
Operations Research	ME3L012	3-0-0	3	3
Computational Fluid Dynamics	ME3L013	3-0-0	3	3
Robotics	ME3L014	3-0-0	3	3
Intermediate Fluid Mechanics	ME3L015	3-0-0	3	3
Elective – II (Semester VII)				
Computer Aided Design and Manufacturing	ME4L002	3-0-3	5	6
Advanced Manufacturing Processes	ME4L004	3-0-3	5	6
Experimental Techniques for Thermo-Fluids Applications	ME6L115	3-0-3	5	6
Non-Conventional Energy Systems	ME6L116	3-0-3	5	6
Elective – III & V (Semester VIII & X)				
Compressible Flows	ME6L152	3-1-0	4	4
MEMS & Microsystems Technology	ME6L062	3-0-0	3	3
Reverse Engineering	ME6L063	3-0-0	3	3
Convective Heat & Mass Transfer	ME6L153	3-0-0	3	3
Conduction and Change of Phase Heat Transfer	ME6L154	3-0-0	3	3
Turbulence	ME6L155	3-0-0	3	3
Microfluidics	ME6L160	3-0-0	3	3
High Performance Computing in Thermo-Fluids Applications	ME6L163	3-0-0	3	3
Numerical Methods in Radiative Heat Transfer	ME6L164	3-0-0	3	3
Geophysical Fluid Dynamics	ME6L166	3-0-0	3	3
Design of Heat Exchangers	ME6L167	3-0-0	3	3
Lattice Boltzmann Modelling	ME6L168	3-0-0	3	3
Fluid Structure Interaction and Separated Flows	ME6L169	3-0-0	3	3
Analytical Combustion	ME6L170	3-0-0	3	3
Mathematical Methods for Mechanical Engineers	ME6L171	3-0-0	3	3
Design and Analysis of Experiments	ID6LXXX	3-0-0	3	3
Research Methodology	HS6LXXX	3-0-0	3	3
Elective – IV (Semester IX)				
Vibrations	ME6L001	3-1-0	4	4
Engineering Measurements	ME6L009	3-1-0	4	4
Operations Management	ME6L010	3-0-0	3	3
Finite Element Methods in Engineering	ME6L011	3-1-0	4	4
Introduction to Nonlinear Dynamics	ME6L014	3-0-0	3	3

Subject Name	Code	L-T-P	Credit	Contact Hour
Conduction & Radiation Heat Transfer	ME6L104	3-0-0	3	3
Air-Conditioning and Ventilation	ME6L107	3-0-0	3	3
Two Phase Flow Heat Transfer	ME6L112	3-0-0	3	3
Spectral Methods for Engineering & Scientific Computing Applications	ME6L113	3-0-0	3	3
Solar Energy	ME6L114	3-0-0	3	3
Introduction to Atmospheric Radiation	ME6L117	3-0-0	3	3
Statistical Thermodynamics	ME6L118	3-0-0	3	3
Micro/Nano Scale Heat Transfer	ME6L119	3-0-0	3	3
Applications of Linear Algebra in Mechanical Engineering	ME6L120	3-0-0	3	3
Data Analytics	ID6LXXX	3-0-0	3	3

Subject Code: ME2L001	Name: Theory of Machines - I	L-T-P: 3-1-0	Credit: 4
Pre-Requisite: None			

Introduction: - Analysis & Synthesis, Terminology, Definition, Types of Mechanism (Planner, Spatial), Mobility, Classification of Mechanisms, Inversions Movability Criteria. Position Analysis - Graphical Method. Analytical Method. Velocity Analysis- Graphical Method, Analytical Method. Instant Centers of Velocity. Acceleration Analysis- Graphical Method, Analytical Method.

Design of Mechanism:- Cam Design: - Introduction, classification of cams & followers. Displacement diagram, Graphical layout of cam profiles, standard cam motions. Gears - Terminology and definition, fundamental law of gearing, Involute properties, interference and Undercutting, Content Ratio, Involumetry, Types of Gears. Gear Train - Simple and Compound Gear Train, Epicyclic Gear Train, Analysis of Planetary Gear by formula and tabular Method, Differentials. Synthesis of linkages- Type, Number and Dimensional Synthesis Function Generation, Path Generation, Two, Three and Four Position Synthesis, Precision Positions, Structural Error, Chebyshev Spacing, Frudenstein's Equation.

Dynamics of Machines: - Static Force - Introduction, Analysis with & without formation, Methodology of Virtual Work. Dynamic Force Analysis - Introduction, Inertia Forces & D. Alembert's Principle, Principle of Superposition, Shaking forces & moments, Complex Algebra Approach. Dynamics of reciprocating Engines - Engine types, Indicator Diagrams, Dynamic Analysis, Equivalent Masses, Inertia Forces, Crankshaft torques, Engine Shaking Forces. Fly Wheel -Dynamic Theory, Integration Techniques, Multicylinder Engine Torque Summation.

Text/Reference Books:

1. Norton R.L., *Design of Machinery*, McGraw-Hill.
2. Myszka D.H., *Machines and Mechanisms: Applied Kinematic Analysis*, Prentice Hall.
3. Bevan T., *Theory of Machines*, CBS Publishers & Distributors, Delhi.
4. Shigley J.E., and Uicker J.J., *Theory of Machines and Mechanisms*, McGraw Hill, Inc.
5. Ghosh A., and Malik A.K., *Theory of Machines and Mechanism*, East-West Press.
6. Wilson C.E., and Sandler J.P., *Kinematics and Dynamics of Machinery*, Pearson Education.

Subject Code: ME2L002	Name: Fluid Mechanics	L-T-P: 3-1-0	Credit: 4
Pre-Requisite: None			

Introduction: properties of fluids, concept of continuum, pressure and stresses; Fluid statics: pressure variation in a static fluid, force on submerged surfaces, stability of floating bodies; Integral relations for Control volume: Reynolds transport theorem – conservation of mass, linear and angular momentum & energy; Differential relations for fluid flow – Acceleration of fluid (Eulerian & Lagrangian), Differential equation for mass continuity, linear momentum & energy; Inviscid & Irrotational Flows: Euler equation, Bernoulli's equation and its applications; Dimensional Analysis & Similitude; Viscous Flows in Pipes: Laminar & Turbulent Pipe flow, friction factor, Moody diagram, hydraulic diameter, minor and major losses; Introduction to boundary layer.

Text/Reference Books:

1. Fox R.W., and McDonald A.T., *Introduction to Fluid Mechanics*, John Wiley & Sons, Inc.
2. White F.M., *Fluid Mechanics*, Tata McGraw Hill Publishing Company Limited.
3. Cengel Y.A., and Cimbala J.M., *Fluid Mechanics: Fundamentals and Applications*, McGraw-Hill

Science/Engineering/Math.

4. Young, Munson, Huebsch, Okiishi, *Fundamentals of Fluid Mechanics*, Wiley.
5. Som S.K. & Biswas G., *Introduction to Fluid Mechanics and Fluid Machines*, Tata McGraw Hill Publishing Company Limited.

Subject Code: ME2L003	Name: Thermodynamics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite: None			

Introduction, Thermodynamic equilibrium; Qasi-static process; Zeroth law and reference points in thermometry; Work and heat transfer; First law for a closed system; Steady flow energy equation; Second law: Kelvin-Planck and Clausius statements; Causes of irreversibility; Carnot's theorem; Absolute temperature scale; Inequality of Clausius; Entropy principle; Entropy transfer and entropy generation; Quality of energy; Energy principle; Guoy-Stodale theorem; Properties of a pure substance; p-v, p-T, T-s and h-s diagrams; Properties of gases and gas mixtures, Equations of state; Law of corresponding states; Maxwell's equations; Joule-Kelvin effect; Clausius-Clapeyron equation; Brayton cycle; Jet propulsion; Turboprop, turbojet and ramjet engines.

Text/Reference Books:

1. Michael A.B., and Cengel Y.A., *Thermodynamics: An Engineering Approach*, Tata McGraw - Hill Education.
2. Van Wylen G.J., and Sonntag R.E., *Fundamentals of Classical Thermodynamics*, John Wiley & Sons Inc.
3. Nag P.K., *Engineering Thermodynamics*, Tata McGraw – Hill.
4. Kumar D.S., *Thermal Science and Engineering*, S. K. Kataria & Sons.

Subject Code: ME2L004	Name: Mechanics of Solids	L-T-P: 3-1-0	Credit: 4
Pre-Requisite: None			

Review of Elementary Mechanics of Materials, Methods of Analysis, Stress – Strain Relations, Failure and Limits on Design. Analysis of Stress and Strain: Definition of Stress at a point, Stress Notation, Symmetry of the stress Array on an Arbitrarily Oriented plane, Transformation of Stress, Principal Stresses, and Other Properties, Differential Equations of Motion of a Deformable Body, Deformation of a Deformable body, Strain Theory, Transformation of Strain, and Principal Strains, Small – Displacement Theory, Strain Measurements and Strain Rosettes. Theories of Failure or Yield Criteria: General Concepts. Applications of Energy Methods. Bending of Straight Beams, Shear Center for Thin – Wall Beam Cross Sections, Curved Beams, Axisymmetric Problems, Torsion and Elastic Stability, Introduction to Fatigue, Creep and Fracture.

Text/Reference Books:

1. Boresi A.P., and Schmidt R.J., *Advanced Mechanics of Solids*, Willey.
2. Srinath L.S., *Advanced Mechanics of Solids*, Tata McGraw – Hill.
3. Timoshenko S.P., *Strength of Materials - (Part 1 & 2)*, CBS Publishers.
4. Timoshenko S.P., and Goodier J.N., Theory of Elasticity, Tata McGraw – Hill.
5. Johnston E.R., Beer F.P., Dewolf J.T., and Mazurek D.F., *Mechanics of Materials (In SI units)* –Tata McGraw – Hill.
6. Hibbeler R.C., *Mechanics of Materials (In SI* units), Pearson Education.
7. Popov E.P., *Engineering Mechanics of Solids*, Prentice-Hall.

Subject Code: ME2L005	Name: Theory of Machines - II	L-T-P: 3-1-0	Credit: 4

Pre-Requisite: None

Kinematics of Particles: Representation of motion of particles in various coordinate systems, relative motion in translating frames, constrained motion; **Kinetics of particles:** Newtons 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'Alemberts principle. Applications: central force motion, impact. **Kinetics of a system of particles**: Newtons 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.

Dynamics of Machinery: Balancing- Static unbalance, Dynamic unbalance, Dynamic balancing, Field balancing, Balancing of single cylinder and multicylinder Engines, analytical technique for balancing multicylinder reciprocating engines. **Governors**- Classification, Centrifugal and inertia governors, Terminology used in Governors- Height, equilibrium speed, Hunting, isochronism, stability, sensitiveness. **Gyroscopes**- Gyroscopic Action in Machines: Angular velocity and acceleration, gyroscopic torque and couple, gyroscopic effect on naval ships **Vibration**- Free Vibration of SDOF Systems: Basic concepts; undamped translational system; Rayleigh's energy method; free vibration with viscous damping. Harmonically Excited Vibration: Equation of motion; undamped response; magnification factor; damped response; energy dissipation.

Text/Reference Books:

1. Beer F.P., and Johnston Jr. E.R., *Vector Mechanics for Engineers: Dynamics*, McGraw-Hill Book Company Inc.
2. Kraige L.G., and Meriam J.L., *Engineering Mechanics - Dynamics*, Wiley.
3. Hibbeler R.C., *Engineering Mechanics - Dynamics*, New Jersey: Pearson Prentice Hall.
4. Norton R.L., *Design of Machinery*, McGraw-Hill.
5. Myszka D.H., *Machines and Mechanisms : Applied Kinematic Analysis*, Prentice Hall.
6. Bevan T., *Theory of Machines*, CBS Publishers & Distributors, Delhi.
7. Shigley J.E., and Uicker J.J., *Theory of Machines and Mechanisms*, McGraw Hill, Inc.
8. Ghosh A., and Malik A.K., *Theory of Machines and Mechanism*, East-West Press.
9. Wilson C.E., and Sandler J.P., *Kinematics and Dynamics of Machinery*, Pearson Education.

Subject Code: ME3L001	Name: Heat Transfer	L-T-P: 3-1-0	Credit: 4

Pre-Requisite: None

Modes of heat transfer, thermal conductivity, combined modes of heat transfer, concept of thermal contact resistance. 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 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. 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. 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. 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. 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. 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.

Text/Reference Books:

1. Incropera, Bergman and DeWitt, *Fundamentals of Heat and Mass Transfer*, John Wiley & Sons Inc.
2. Cengel Y., *Heat Transfer: A Practical Approach*, McGraw-Hill Professional.
3. Ozisik M.N., *Heat Transfer: A Basic Approach*, McGraw-Hill Companies.
4. Holman J.P., *Heat Transfer*, McGraw-Hill.
5. Bejan A., *Convection Heat Transfer*, Wiley.

Subject Code: ME3L002	**Name: Design of Machine Elements**	**L-T-P: 3-0-0**	**Credit: 3**

Pre-Requisite: None

Introduction to Mechanical Engineering Design; Failure Preventions; Materials; Factor of Safety; Fits and Tolerances; Welding, Bonding, and the Design of Permanent Joints; Screws, Fasteners, and the Design of Non-Permanent Joints; Shafts; Clutch, Brakes, Couplings, and Flywheel; Mechanical Springs; Lubrication and Bearings; Gears - General; Flexible Mechanical Elements.

Text/Reference Books:

1. Shigley J.E., *Shigley's Mechanical Engineering Design*, McGraw Hill.
2. Norton R.L., *Machine Design 'An Integrated Approach'* , Pearson.
3. Spotts M.F., *Design of Machine Elements*, Pearson.
4. Bhandari V.B., *Design of Machine Elements*, McGraw Hill.
5. Khurmi R.S., and Gupta J.K., *Machine Design,* S Chand.
6. Lingaiah K., *Machine Design Data Book*, Tata McGraw – Hill.

Subject Code: ME3L003	Name: Casting, Welding and Forming (CWF)	L-T-P: 3-0-0	Credit: 3
Pre-Requisite: None			

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. 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. 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.

Text/Reference Books:

1. Kalpakjin S, *Manufacturing Engineering and Technology*, Pearson Education.
2. Rao P.N., *Manufacturing Technology*, Tata McGraw – Hill.
3. Jain R.K., *Production Technology*, Khanna Publishers.
4. Lindberg, *Process and materials of manufacturing*, Pearson Education.
5. Heine R. W., Loper C. R. and Rosenthal P. C., *Principles of Metal Castings*, Tata McGraw – Hill.
6. Parmar R. S., *Welding Process and Technology*, Khanna Publishers.
7. Sharma P. C., *A Textbook of Production Technology*, S Chand.
8. Dalela S., and Shankar R., *Production Engineering*, Galgotia Publications Pvt. Ltd.

Subject Code: ME3L005	Name: IC Engines	L-T-P: 3-0-0	Credit: 3
Pre-Requisite: None			

Engine Classification, Components, Carnot Cycle, Stirling Cycle, Ericsson Cycle, Lenoir Cycle, Atkinson Cycle, Air standard Cycles: Otto, Diesel and Dual cycles, Fuel-Air and Actual cycles' comparison**.** Working principles and comparison of 2-stroke and 4-stroke SI & CI engines, Valve Timing Diagram. Important Qualities and Ratings of SI & CI Engine Fuels, Dopes, Gas Turbine Fuels. Magneto Ignition System, Battery Ignition System and Modern Ignition System for S.I. Engines, Ignition Timing. Combustion in SI & CI Engines : Stages of combustion, Ignition lag and factors affecting the lag, Flame propagation and factors affecting the propagation in SI engine, Abnormal combustion, Detonation or Knocking, Factors affecting knocking, Effects of knocking, Control of Knocking, Combustion Chambers. Simple Carburetor, Drawbacks, Complete Carburetor, Compensation. Fuel Injection of CI and SI Engines : Introduction, Requirement and Types of Injection System, MPFI System in SI engine. Engine Heat Transfer, Engine cooling and lubrication: Principle and description. Supercharging of SI and CI engines, Effect of supercharging, Limitation of supercharging, Superchargers. Performance Parameters, Measurements & Testing of I C Engines, Engine Indicator and its use, Heat balance. Pollutant Formation & its Control.

Text/Reference Books:

1. Taylor C.F., *Internal-combustion engine in theory and practice*, Cabridge University Press.
2. Ferguson C.R., and Kirkpatrick A.T., *Internal combustion engines : Applied Thermosciences*, John Wiley & Sons.

3. Heywood J.B., *Internal combustion engine fundamentals*, McGraw-Hill.
4. Ganesan V., *Internal combustion engines*, McGraw-Hill.
5. Rogowski A.R., *Elements of internal-combustion engines*, McGraw-Hill.

Subject Code: ME3L006	Name: Refrigeration & Air Conditioning	L-T-P: 3-0-0	Credit: 3

Pre-Requisite: Thermodynamics

Refrigeration Cycles; Thermodynamic analysis of vapour-compression, aircraft refrigeration systems; Application and optimization of multistage and cascade refrigeration systems; Fan, pump, evaporator and condenser selection; Vapour absorption refrigeration systems; Refrigerants; multistage refrigeration; Load calculations; Design of various elements of a refrigeration unit.

Brief history of airconditioning; Principles of psychrometry, psychrometry of airconditioning processes, comfort chart, indoor and outdoor design conditions, comfort air conditioning.

Text/Reference Books:

1. Ameen A., *Refrigeration and Air Conditioning*, Prentice Hall India Learning.
2. Stocker W.F. and Jones J.W., *Refrigeration and Air Conditioning*, McGraw-Hill Publishing Company.
3. Dossat R.J., *Principle of Refrigeration*, Wiley.
4. Arora C.P., *Refrigeration and Air Conditioning*, McGraw-Hill.
5. Rajput R.K., *Refrigeration and Air Conditioning*, S. K. Kataria & Sons.

Subject Code: ME3L007	Name: Machine Tools & Machining	L-T-P: 3-0-0	Credit: 3

Pre-Requisite: None

Machine tools:- Concept and definition of machining and machine tools. History of developments of machine tools. Kinematic schemes 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.

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.

Text/Reference Books:

1. Rao P.N., *Manufacturing Technology, metal cutting & Machine tools*, Tata McGraw-Hill.
2. Boothroyd G., *Fundamentals of metal machining and machine tools*, Taylor & Francis.
3. Jain R.K., and Gupta S.C., *Production Technology*, Hindustan Machine Tools.
4. Hazra Chowdary S.K., *Elements of Workshop Technology –Vol II*, Media Promoters.
5. Ghosh A., and Mallik A.K., *Manufacturing science*, East-West Press.

Subject Code: ME3L008	Name: Power Plant Engineering	L-T-P: 3-0-0	Credit: 3

Pre-Requisite: None

Introduction to Power Plant, Analysis of steam cycles, optimization of reheat pressure and degree of regeneration, coupled cycles and combined plants, process heat and power. Boilers: Different types of boilers, boiler mountings & accessories, feed water treatment, boiler energy balance & draft system. Nozzles; convergent and convergent-divergent nozzles - theory and design. Steam Turbines: Impulse and reaction turbines, compounding of turbines, optimum velocity ratio, reheat factor and condition line, parallel exhaust, losses in steam turbines, steam turbine governing. Theory and design of condensers, air ejector and cooling tower. Fluid Power & Machinery: Similarity, Euler equation for Turbo-machines, Centrifugal pump, Hydraulic turbines, Cavitation.

Text/Reference Books:

1. El-Wakil M.M., *Power Plant Technology*, McGraw-Hill Science/Engineering/Math.
2. Nag P.K., *Power Plant Engineering*, Tata McGraw Hill Publishing Company Limited.
3. Veatch B., Drbal L.F., Boston P.G., Westra K.L., Erickson R.B., *Power Plant Engineering*, CBS Publishers.
4. Rajput R.K., *A Textbook of Power Plant Engineering*, Laxmi Publication.
5. Som S.K., and Biswas G., *Introduction to Fluid Mechanics and Fluid Machines*, Tata McGraw Hill Publishing Company Limited.

Subject Code: ME6L101	**Subject Name: Name: Advanced Fluid Dynamics**	**L-T-P: 3-1-0**	**Credit: 4**
Pre-Requisite(s): Fluid Mechanics			

Introduction to Tensors & Tensors Equations. 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, dilation, strain, rotation and vorticity. Strain rate & rotation rate tensors. Continuity equation, stream function and velocity potential. Transport theorems, constitutive equations, Derivation of Navier-Stokes equations for compressible flow, Newtonian Fluid & Constant Property Incompressible Navier-Stokes equation. Exact solutions of Navier Stokes equations. Slow viscous flow: Stokes and Oseen's approximation. Theory of hydrodynamic lubrication. Boundary layers: Exact, Approximate & Numerical solutions. Free Shear Flows – Jets & Wakes. Introduction to Turbulent Flow – Reynolds Stress, Turbulent Viscosity Hypothesis.

Text/Reference Books:

1. Panton R.L., *Incompressible Flow*, Wiley.
2. White F.M., *Viscous Fluid Flow*, McGraw-Hill.
3. Schlichting H., and Gersen K., *Boundary Layer Theory*, Springer.
4. Batchelor G.K., *An Introduction to Fluid Dynamics,* Cambridge University Press.
5. Pope S.B., *Turbulent Flows,* Cambridge University Press
6. Aris R., *Vectors, Tensors and the Basic Equations of Fluid Mechanics,* Dover Publications.
7. Kundu P.K., and Cohen I.M., *Fluid Mechanics with Multimedia DVD,* AP / Elsevier.
8. *Munson B.R., Young D.F., Okiishi T.H., and Huebsch W.W.,* F*undamentals of Fluid Mechanics* Wiley.
9. Davidson P.A., *Turbulence, An Introduction for Scientists and Engineers,* Oxford.
10. Townsend A.A., *The Structure of Turbulent Shear Flows*, Cambridge University Press.

Subject Code: ME6L102	**Subject Name: Computational Methods in Thermal and Fluids Engineering**	**L-T-P: 3-1-0**	**Credit: 4**
Pre-Requisite(s): None			

A brief overview of the basic conservation equations for fluid flow and heat transfer, classification of partial differential equations and pertinent physical behaviour, parabolic, elliptic and hyperbolic equations, role of characteristics. Common methods of discretization: an overview of finite difference, finite element and finite volume methods. Numerical solution of parabolic partial differential equations using finite-difference and finite-volume methods: explicit and implicit schemes, consistency, stability and convergence. Numerical solution of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination, LU decomposition, tri-diagonal matrix algorithm, Jacobi and Gauss-Seidel iterations, necessary and sufficient conditions for convergence of iterative schemes.The finite volume method of discretization for diffusion problems: one-dimensional steady diffusion problems, specification of

interface diffusivity, source-term linearization. Discretization of transient one-dimensional diffusion problems. Discretization for multi-dimensional diffusion problems. Solution of discretized equations using point and line iterations, strongly implicit methods and pre-conditioned conjugate gradient methods.
Convection-diffusion problems: Central difference, upwind, exponential, hybrid and power-law schemes, concept of false diffusion.Numerical solution of the Navier-Stokes system for incompressible flows: stream-function vorticity and artificial compressibility methods, requirement of a staggered grid. SIMPLE, SIMPLEC and SIMPLER algorithms.Special topics: phase-change problems, interface/free-surface tracking methods.

Text/Reference Books:

1. *Numerical Heat Transfer and Fluid Flow 1ed*, 2004 - Suhas V. Patankar, - Taylor and Francis
2. *Introduction to Computational Fluid Dynamics: The Finite Volume Method 2ed*, 2008 - H. K. Versteeg and W. Malalasekera – Pearson
3. *Computational Fluid Dynamics 1ed*, 1995 - D. A. Anderson Jr - McGraw-Hill
4. *Computational Fluid Mechanics and Heat Transfer* - John C. Tannehill, Dale A. Anderson and Richrad H. Pletcher - Taylor and Francis Group, 1997
5. *Introduction to Computational Fluid Dynamics* 2005 - Anil W. Date, Cambridge University Press
6. *Computational Fluid Flow and Heat Transfer 2ed,* 2009 - K. Muralidhar and T. Sundararajan - Narosa
7. *Numerical Solution of Partial Differential Equations: Finite Difference Methods 3ed*, 1986 - G. D. Smith - Oxford University Press

Subject Code: ME6L151	**Subject Name: Advanced Heat Transfer**	**L-T-P: 3-1-0**	**Credit: 4**
Pre-Requisite(s): None			

Review of Conduction Heat Transfer, Multi-dimensional Conduction, Unsteady Conduction Heat Transfer, A review of viscous flow, the continuity and Navier-Stokes equation, boundary layer equation, laminar boundary layer over a flat plate, Energy equation, derivation of energy equation, energy equation in non-dimensional form, derivation of thermal boundary layer equation, heat transfer in a parallel flow over a flat surface, analogy between momentum and heat transfer in turbulent flow, forced convection in internal flows, concept of entrance length and fully developed flow, heat transfer in high speed flow; Governing equation, Scaling laws, free convection in laminar flow over a vertical plate, empirical co-relation in external free convection flows, inclined plates, long horizontal cylinder, spheres, free convection in enclosures, and cavities, concentric cylinders, concentric spheres, combined free and forced convection, Basic design methodologies-LMTD and effectiveness-NTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor, Heat transfer in boiling, forced convection boiling, Condensation heat transfer, theory of film condensation, drop wise condensation, heat pipes, heat transfer in freezing and melting; Mechanism and fundamental concepts, definition of concentration, mass fluxes and mole fluxes, Ficks law of diffusion, temperature and pressure dependence of mass diffusivity, diffusion in a multi component system, theory of diffusion in gases and liquids, mass transfer coefficient, simultaneous heat and mass transfer.

Text/Reference Books:

1. *Fundamentals of Heat and Mass Transfer* – Incropera & Dewitt-Wiley
2. *Heat and Mass Transfer* - Cengel&Ghajar-McGraw Hill

3. *Heat Transfer : A Basic Approach* - M. N. Ozisik - McGraw Hill
4. *Heat Transfer* – Mills & Ganeshan - Pearson
5. *Heat Transfer* - J. P. Holman - McGraw Hill
6. *Convective Heat Transfer* - A. Bejan - Wiley
7. *Computation of Conduction and Duct Flow Heat Transfer* - S. V. Patankar - CRC Press
8. *Process Heat Transfer* - D. Q. Kern - McGraw Hill

Elective – I (Semester VI)

Subject Code: ME3L012	Subject Name: Operations Research	L-T-P: 3-0-0	Credit: 3

Pre-requisite(s): None

Formulation Linear Programming, Graphical method, Simplex method, Duality, Transportation problem: Optimality test, Special cases of Assignment Problem, Sequencing Problem, Game Theory, Project scheduling, Queuing Theory.

Text/Reference Books:

1. *Hillier F.S., and Lieberman G.J., Introduction to Operations Research, Tata McGraw Hill, New York.*
2. *Taha H.A., Operations Research: An Introduction, Prentice-Hall, New York.*
3. *Winston W.L., Operations Research: Applications and Algorithms, Duxbury Press, Belmont.*
4. *Ravindran and Phillip, Operations Research, Wiley publication.*

Subject Code: ME3L013	Subject Name: Computational Fluid Dynamics	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): Fluid Mechanics

Basic conservation equations for fluid flow and heat transfer, classification of partial differential equations and pertinent physical behavior, parabolic, elliptic and hyperbolic equations, role of characteristics; Common methods of discretisation: an overview of finite difference and finite volume methods; Numerical solution of parabolic partial differential equations using finite-difference and finite-volume methods: explicit and implicit schemes; Consistency, stability and convergence; Numerical solution of systems of linear algebraic equations: iterative methods, tridiagonal matrix algorithm, Jacobi and Gauss-Seidel iterations, necessary and sufficient conditions for convergence of iterative schemes; The finite volume method of discretisation for diffusion problems; Convection-diffusion problems; Numerical solution of the Navier-Stokes system for incompressible flows.

Text/Reference Books:

1. Patankar S.V., *Numerical Heat Transfer and Fluid Flow*, Taylor and Francis.
2. Versteeg H.K., and Malalasekera W., *Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson Publisher.
3. Tannehill J.C., Anderson D.A., and Pletcher R.H., *Computational Fluid Mechanics and Heat Transfer*, Taylor and Francis Group.
4. Anderson Jr. D.A., *Computational Fluid Dynamics*, McGraw-Hill Publisher.
5. Smith G.D., *Numerical Solution of Partial Differential Equations: Finite Difference Methods*, Oxford University Press.

Subject Code: ME3L014	Subject Name: Robotics	L-T-P: 3-0-0	Credit: 3

Pre-requisite(s): None

Introduction, brief history, components, types and classification of robots, Homogeneous transformations, representation of joints and links using D-H parameters, direct and inverse kinematics of manipulators, examples of kinematics of some common manipulator configurations, Jacobian and dynamics of manipulators, trajectory planning; Purpose and types of sensors, Internal and external sensors, common sensors–displacement sensors, velocity sensors, force sensors and vision, necessity of actuators, different kinds of

actuators – stepper motors, DC servo and brushless motors, programming of robots.

Text/Reference Books:

1. Ghosal A., *Robotics: Fundamental concepts and analysis*, Oxford university press.
2. Groover M.P., *Industrial Robotics*, Pearson Education.
3. Mittal R.K., and Nagrath I.J., *Robotics and Control,* Tata Mc-Graw Hill.
4. Fu K., Gonzalez R., and Lee C. S. G., *Robotics: Control, sensing, vision and intelligence*, McGraw Hill.
5. Klafter R.D., *Robotic Engineering*, Prentice Hall.
6. Craig J.J., *Introduction to Robotics*, Pearson Education.
7. Spong M.W., and Vidyasagar M., *Robot Dynamics & Control,* John Wiley & Sons (ASIA) Pte Ltd.
8. Saha S.K., *Introduction to robotics*, Tata Mc-Graw Hill.
9. Jazar R.N., *Theory of applied robotics, kinematics, dynamics and control*, Springer.

Subject Code: ME3L015	**Subject Name: Intermediate Fluid Mechanics**	**L-T-P: 3-0-0**	**Credit: 3**
Pre-Requisite(s): Fluid Mechanics			

Review: Differential form of Conservation Equations of Mass, Momentum & Energy, N-S Equations for Incompressible Flows; Velocity Potential, Stream-function; Vorticity & Circulation; Potential Flows – Elementary plane flows, superposition, plane flow past closed body shapes, flow past cylinder (Lifting & Non-lifting) – lift & drag, Complex Potential & Conformal mapping, Image & Reflections, Applications to plane flows; Vortex Lines, Kelvin-Helmhotz Theorems, Biot-Savart Law & Induced Velocity; Airfoil theory – Kutta conditions, lifting-line theory; Boundary Layer – Equations, Approximate & Exact solutions; Introduction to Stability, Transition & Turbulence.

Text/Reference Books:

1. White F.M., *Fluid Mechanics*, Tata McGraw Hill Publishing Company Limited.
2. Anderson J.D., *Fundamentals of Aerodynamics*, McGraw Hill.
3. Fox R.W., and McDonald A.T., *Introduction to Fluid Mechanics*, John Wiley & Sons, Inc.
4. Panton R.L., *Incompressible Flow*, Wiley.
5. White F.M., *Viscous Fluid Flow,* McGraw-Hill.
6. Schlichting H., and Gersten K., *Boundary Layer Theory,* Springer.
7. Kundu P.K., and Cohen I.M., *Fluid Mechanics with Multimedia DVD*, AP / Elsevier.
8. Munson B.R., Young D.F., Okiishi T.H., and Huebsch W.W., *Fundamentals of Fluid Mechanics,* Wiley.

Elective – II (Semester VII)

Subject Code: ME4L002	Subject Name: Computer Aided Design & Manufacturing	L-T-P: 3-0-3	Credit: 5

Pre-Requisite(s): Engineering Drawing & Graphics

Overview of CAD, Software and hardware requirements of CAD, CAD applications, solid modeling, wire frame modeling, B-rep, CSG approaches, Transformations and projections, Mathematical representation of curves and surfaces, Cubic, Bezier and B-spline curves and properties; Introduction to NC, components, advantages and limitations of NC, CNC, DNC, part programming, adaptive control, group technology, computer aided process planning, FMS and CIM.

Laboratory

Generation of various 3D models through protrusion, revolve and shell sweep and their assembly modelling using any of the CAD modelling software. Determination of deflection and stresses in 2D and 3D trusses and beams. Determination of principal and von-mises stresses in plane stress, plane strain and axi-symmetric components. Determination of stresses in 3D and shell structures. Estimation of natural frequencies and mode shapes in beams using analysis package. Generation of part programs on CNC turning and milling machines to produce free form and sculptured surfaces using CAM package.

Text/Reference Books:

1. Zimmers & Groover P., *CAD/CAM*, PE/PHI Publishers.
2. Zeid I., *CAD / CAM Theory and Practice,* Tata McGraw – Hill.
3. Rao P.N., *CAD/CAM principles and applications*, Tata McGraw – Hill.
4. Korean Y., *Computer control of Machine Tools and Processes*.
5. Groover, *Automation , Production systems & Computer integrated Manufacturing*, Pearson Education.
6. Amirouche F., *Principles of Computer Aided Design and Manufacturing*, Pearson Education.
7. Seames W.S., *Computer Numerical Control Concepts and programming*, Thomson Learning.

Subject Code: ME4L004	Subject Name: Advanced Manufacturing Processes	L-T-P: 3-0-3	Credit: 5

Pre-Requisite(s): Introduction to Manufacturing Process

Industrial needs and problems in manufacturing. Probable principles in achieving the solutions through non-conventional energy sources. Classifications and sources for hybridization of processes. Erosion theories and principles of their uses through different Mechanical processes, e.g. Ultrasonic, Abrasive-jet and fluid flow. Principles and analyses of crack & stress free processes, e.g. Chemical processing and Electrochemical processing of materials. Principles and analyses of thermal processing materials and their uses through Electrical Discharges (EDM/WEDM), Laser, Electron and Ion Beam, Plasma processing. Processing of materials through hybridization to achieve desired surface integrity and surface quality. Emerging trends in Material processing: introduction to RPT and macro-micro-nano manufacturing.

Laboratory

Orientation to Non-conventional machine; Exposure to EDM/WEDM/EB, quantifications of process parameters and their effects; Exposure to Laser with relevant experiments to quantities its effect on materials for different operations. Hybridization of processes, solid/liquid (US/AJ/WJ) impact erosion studies. Manufacturing using CHM/PCM for

manufacturing of micro components. Exposure to high precision measuring instruments, e.g. Roughness: contact/noncontact type, Sample preparation for micro structural and hardness studies etc., Promoting innovations through hands on experimentations & Audio-video studies.

Text/Reference Books:

1. *ASHRAE Handbook - Fundamentals*, *American Society of Heating, Refrigerating and Air - Conditioning Engineers Inc*., Atlanta, USA, 2009.
2. Threlkeld, J.L., *Thermal Environmental Engineering*, Prentice Hall, New Jersey, 1962.
3. Croome, D.J. and Roberts, B.M., *Air conditioning and ventilation of buildings*, Pergamon.
4. Stoecker, W.F., and Jones, J.W., *Refrigeration and Air Conditioning*, 2nd Edition, Tata McGraw Hill, New Delhi 1982.
5. Arora, C.P., *Refrigeration and Air Conditioning*, Tata-McGraw-Hill, New Delhi, 2003.

Subject Code: ME6L115	**Subject Name: Experimental Techniques for Thermo-Fluids Applications**	**L-T-P: 3-0-3**	**Credit: 5**
Pre-Requisite(s):			

Introduction to experimental data collection and analysis, in particular as they pertain to fluid flows. Covers computer-based experimental control, analog and digital data acquisition, discrete sampling theory, digital signal processing, uncertainty analysis. Also covers: Analog Transducers, Hot-wire/Hot-Film & Cold-Wire/Cold-Film Anemomentry, Acoustic and Laser Doppler velocimetry, Ultrasound velocity profiling, Full-field (2-D) quantitative imaging techniques like PIV& PLIF; Particle based techniques – PTV & PDPA, Optical Density Based Techniques – Schlieren, Shadograph, Thermocouple, Heat flux gauges, Thermal imaging, Infrared thermography, Liquid crystal thermography, multi-phase flow measurement.

Laboratory

Flow visualization, Steady and unsteady pressure measurements, Measurement of velocity and temperature in transitional and turbulent flow fields using Hot-wire/Hot-Film & Cold-Wire/Cold-Film Anemomentry, Characterization of flows based on coherent structures using PIV and PLIF, Thermocouple calibration, Impinging jet heat transfer studies using Infrared camera, Qualitative and quantitate estimation of density gradients using Schlieren and Shadography.

Text/Reference Books:

1. Tropea C et al, *Springer Handbook of Exprimental Fluid Mechanics*, Springer
2. R. J. Goldstein, *Fluid Mechanics Measurement*, Hemisphere publishing
3. Müller U., Roesner K.G., and Schmidt B., *Recent Developments in Theoretical and Experimental Fluid Mechanics: Compressible and Incompressible Flows*, Springer.
4. Tavoularis S., *Measurement in Fluid Mechanics*, Cambridge Univ. Press.
5. Panton R.L., *Incompressible Flow*, Wiley.
6. White F.M., *Viscous Fluid Flow*, McGraw-Hill.

Subject Code: ME6L116	Subject Name: Non-Conventional Energy Systems	L-T-P: 3-0-3	Credit: 5
Pre-Requisite(s):			

Introduction, Fossil fuel based systems, Impact of fossil fuel based systems, Non-conventional energy, Seasonal variations and availability, Renewable energy sources and features, Hybrid energy systems, Distributed energy systems and dispersed generation (DG), Traditional Energy Systems, Solar Thermal Systems, Solar radiation spectrum, Radiation measurement, Solar energy for heating, cooling, drying, distillation and power generation, Solar Photovoltaic Systems, operating principles, Photovoltaic cell concepts, Cell, module, array, Series and parallel connections, Maximum power point tracking, Microhydel and operating principles, Components of a microhydel power plant, Types and characteristics of turbines, Selection and modification, Load balancing, Wind, Wind patterns and wind data, Types of windmills, Characteristics of wind generators, Load matching, Biomass and operating principles, Combustion and fermentation, Anaerobic digester, Wood gasifier, Pyrolysis, Biogas, Wood stoves, Bio diesel, Combustion engine, Wave Energy Systems, Near shore systems, off shore systems, Costing, Life cycle costing (LCC), Solar thermal system LCC, Solar PV system LCC, Microhydel LCC, Wind system LCC, Biomass system LCC, Hybrid Systems, Need for Hybrid Systems. Range and type of Hybrid systems. Case studies of Diesel-PV, Wind-PV, Microhydel-PV, Biomass-Diesel systems, electric and hybrid electric vehicles

Laboratory

Solar Radiation Measurement, Solar Distillation, Solar Pumping, Solar Cooker, Solar Air & Water Heater Thermosiphon & Forced Circulation, Solar Lanterns and Street light, Fuel cell, Wind Turbine

Text/Reference Books:

1. S. P. Sukhatme, *Solar Energy - Principles of thermal collection and storage,* second edition, Tata McGraw-Hill, New Delhi, 1996
2. J. A. Duffie and W. A. Beckman, *Solar Engineering of Thermal Processes,* second edition, John Wiley, New York, 1991
3. D. Y. Goswami, F. Kreith and J. F. Kreider, *Principles of Solar Engineering,* Taylor and Francis, Philadelphia, 2000
4. D. D. Hall and R. P. Grover, *Biomass Regenerable Energy*, John Wiley, New York, 1987.
5. J. Twidell and T. Weir, *Renewable Energy Resources,* E & F N Spon Ltd, London, 1986.

Elective – III & V (Semester VIII & X)

Subject Code: ME6L152	Subject Name: Compressible Flows	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): Fluid Mechanics, Thermodynamics			

Fundamental Aspects of Compressible Flow: Introduction, Isentropic flow in a stream tube, speed of sound, Mach waves; One dimensional Isentropic Flow; Normal Shock Waves; Oblique Shock Waves; Prandtl-Meyer Expansion; Flow over bodies involving shock and expansion waves; Variable Area Flow, operating characteristics of nozzles, convergent-divergent supersonic diffusers; Adiabatic Flow in a Duct with Friction : Flow in a constant area duct, friction factor variations, the Fanno line; Flow with Heat addition or Removal.

Review of Eigen Vectors & Eigen Values, Linearization of PDEs, Perturbation; Introduction to Instability & Transition of Fluid Flows; Linear Stability & Normal Modes as Perturbations; KH Instability; Stability of Parallel Flows, Orr-Sommerfield Equation; Blasius Boundary Layer – Secondary Instability & Bypass Transition.

Text/Reference Books:

1. Anderson J.D., *Modern Compressible Flow with Historical Perspective,* McGraw-Hill
2. Shapiro A.H., *The Dynamics & Thermodynamics of Compressible Fluid Flow (Vol 1 &Vol 2).*, Wiley.
3. Panton R.L., *Incompressible Flow*, Wiley.
4. White F.M., *Viscous Fluid Flow*, McGraw-Hill.
5. Schlichting H., and Gersten K., *Boundary Layer Theory,* Springer.
6. John J., and Keith T., *Gas Dynamics,* Pearson.
7. Liepmann H.W., and Roshko A., *Elements of Gas Dynamics*, Dover.
8. Balachandran P., *Gas Dynamics for Engineers,* PHI.
9. Balachandran P., *Fundamentals of Compressible Fluid Dynamics,* PHI.

Subject Code: ME6L062	Subject Name: MEMS & Microsystems Technology	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Introduction to MEMS & MST. Scaling Laws and demand in miniaturization. Working principles of Micro Sensors, Actuators and applications in real systems. Microsystems mechanisms & precision using flexures, design considerations, modeling and innovations. Materials selection, Micro Fabrication. Microfluidics, Chemical Sensors, Biomedical & Bio-MEMS, and Lab-on-a-chip. System Integration and Packaging.

Text/Reference Books:

1. Hsu T.R., *MEMS & MICROSYSTEMS Design and Manufacture*, Tata McGraw Hill Education Pvt. Ltd.
2. Madou M., *Fundamentals of Microfabrication: The Science of Miniaturization*, *Vol. I, II, & III*, CRC Press.
3. Senturia S.D., *Microsystems Design*, Springer.

Subject Code: ME6L063	Name: Reverse Engineering	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Forward Engineering Design, Design Thought and Process, Design Steps, System RE, RE Methodology, RE Steps, System level Design, and Examples, Product Development, Product Functions, Engineering Specifications, Product Architecture, Mechanical RE, Computer-Aided RE, Electronic RE, Identify electronic components, PCB RE,

Schematic Drawings and Analysis, S/W RE, Reverse Engineering in Computer Applications, Re-engineering of PLC programs etc.

Text/Reference Books:

1. K. Otto and K. Wood, P*roduct Design: Techniques in Reverse Engineering and New Product development*, Prentice Hall, 2001.
2. Raja and Fernandes, *Reverse Engineering: An Industrial Perspective*, Springer-Verlag 2008.
3. *Reverse Engineering in Computer Applications*. MIT Lecture Notes 2001.
4. Sokovic and Kopac, *RE as necessary phase by rapid product development*. Journal of Materials Processing Technology 2005.
5. Deno, Landis, Hulina, and Sanjay, A Rapid Prototyping Methodology for Reverse Engineering of Legacy Electronic Systems by IEEE International Workshop on Rapid System Prototyping, 1999.

Subject Code: ME6L153	**Subject Name: Convective Heat & Mass Transfer**	**L-T-P: 3-0-0**	**Credit: 3**
Pre-Requisite(s): Fluid Mechanics, Heat Transfer			

Forced Convective Heat Transfer: Introduction to heat transfer by convection, a review of viscous flow, conservation of mass and momentum – the continuity and Navier-Stokes equation, boundary layer equation, laminar boundary layer over a flat plate, boundary layer separation, energy equation, derivation of energy equation, energy equation in non-dimensional form, derivation of thermal boundary layer equation, heat transfer in a parallel flow over a flat surface, analogy between momentum and heat transfer in turbulent flow, heat transfer in parallel flow and cross flow over a cylinder, heat transfer in parallel flow over a sphere, heat transfer for impinging jets, forced convection in internal flows, concept of entrance length and fully developed flow, heat transfer in high speed flow;

Natural Convection Heat Transfer: Governing equation and similarity considerations, free convection in laminar flow over a vertical plate, empirical co-relation in external free convection flows, inclined plates, long horizontal cylinder, spheres, free convection in enclosures, and cavities, concentric cylinders, concentric spheres, combined free and forced convection. Heat Transfer with Phase Change: Heat transfer in boiling, modes of boiling, regimes of pool boiling, pool boiling correlation, critical heat flux in nucleate pool boiling, forced convection boiling, modes of condensation, theory of film condensation, laminar and turbulent film condensation on a vertical plate, film condensation inside and outside horizontal tubes, drop wise condensation, heat pipes, theory of heat pipes, design limitations, heat transfer in freezing and melting; Mass Transfer: Mechanism and fundamental concepts, definition of concentration, mass fluxes and mole fluxes, Ficks law of diffusion, temperature and pressure dependence of mass diffusivity, diffusion in a multi component system, theory of diffusion in gases and liquids, mass transfer coefficient, conservation of species for a control volume – species continuity equation, equimolar counter diffusion, simultaneous heat and mass transfer.

Text/Reference Books:

1. Kays W.M., and Crawford M.E., *Convective Heat and Mass Transfer*, McGraw Hill Int Edition.
2. Spalding D.B., *Introduction to Convective Mass Transfer*, McGraw Hill.
3. Bird R.B., Stewart W.E., and Lightfoot E.N., *Transport Phenomena*, John Wiley and sons, Inc.
4. Schlichting H., *Boundary Layer Theory*, McGraw Hill.

Subject Code: ME6L154	Subject Name: Conduction and Change of Phase Heat Transfer	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): None

Solutions of steady and transient heat conduction problems with various boundary conditions. Approximate methods: application of numerical techniques. Moving boundaries: problems in freezing and melting. Condensation heat transfer. Boiling: mechanisms and heat transfer correlations. Thermal modeling of engineering systems: thermal contact resistance; heat and mass transfer in material processing; heat transfer in biomedical systems.

Text/Reference Books:

1. *Liquid Vapor Phase Change Phenomena* by Van P. Carey (Taylor & Francis).
2. *One Dimensional Two-Phase Flow* G. B. Wallis (McGraw Hill).
3. *Heat Pipe Science and Technology* by Amir Faghri (Taylor and Francis).
4. *Convective Boiling And Condensation* by Collier John (Oxford Engineering Science)
5. *Two-phase Flow and Heat Transfer* - P. B. Whalley (Oxford Engineering Science)
6. *Heat Transfer Characteristics in Boiling and Condensation* by Karl Stephan (Springer)
7. *Heat Pipe Technology and Applications* by J. P. Peterson (John Wiley & Sons)
8. *Heat Transfer* - A practical approach by Yunus Cengel (Tata McGraw Hill)
9. *Heat Transfer* - Incropera and Dewitt (John Wiley and Sons)

Subject Code: ME6L155	Subject Name: Turbulence	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): Fluid Mechanics

Review of Tensor Equations, Stochastic Processes, Probability & Averaging; Reynolds averaging, Reynolds Stresses, RANS equations, Turbulent Viscosity Hypothesis; Free-Shear Flows – Round Jet, Similarity, Turbulent kinetic energy and kinetic energy of mean flow - convection, production and dissipation of turbulence, re-distribution, turbulent diffusion; Other Self-Similar Flows – Homogenous Shear, Wind Tunnel Turbulence, Mixing Layer; Statistical Description of Turbulence - stationary and non-stationary turbulence, homogeneous and non-homogeneous turbulence, nonlinearity, two-point correlations, structure functions, turbulence scales, energy cascade, vortex stretching, velocity spectra & energy spectrum; Wall bounded flows – Channel flow, Boundary Layer, Near wall velocity & turbulence quantities profile , Equations for Reynolds stresses & TKE balance; Introduction to Turbulence Modeling – Mixing Length Model & k-ε model.

Text/Reference Books:

1. Pope S.B., *Turbulent Flows*, Cambridge University Press.
2. Mathieu J., and Scott J., *An Introduction to Turbulent Flow*, Cambridge University Press.
3. Davidson P.A., *Turbulence: An Introduction for Scientists and Engineers*, Oxford.
4. Tennekes H., and Lumley J.L., *A First Course in Turbulence*, MIT Press.
5. Hinze J.O., *Turbulence*, McGraw-Hill.
6. Batchelor G.K., *Theory of Homogenous Turbulence*, Cambridge University Press.
7. Frish U., *A Legacy of A. N. Kolmogorov Turbulence*, Cambridge University Press.
8. Schlichting H., and Gersten K., *Boundary Layer Theory*, Springer.
9. Monin A.S., and Yaglom A.M., *Statistical Fluid Mechanics (Vol I & Vol II)*, Dover.

Subject Code: ME6L160	Subject Name: Microfluidics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

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 microscaleCouette 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 electroosmosis, 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, leuokocyte rolling etc.), An introduction to special computational modelling of micro-flows: MD and DSMC methods.

Text/Reference Books:

1. *Fundamentals and Applications of Microfluidics*, Nam-Trung Nguyen, Steven T. Wereley, Artech House (2002).
2. *Theoretical Microfluidics*, HenrikBruus, Oxford University Press, (2008).
3. Nguyen, N. T., Werely, S. T., *Fundamentals and applications of Microfluidics*, Artech house Inc., 2002.
4. Bruus, H., *Theoretical Microfluidics*, Oxford University Press Inc., 2008.
5. Madou, M. J., *Fundamentals of Microfabrication*, CRC press, 2002.
6. Tabeling, P., *Introduction to microfluidics*, Oxford University Press Inc., 2005.
7. Kirby, B.J., *Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices*, Cambridge University Press, 2010.
8. Colin, S., *Microfluidics*, John Wiley & Sons, 2009.

Subject Code: ME6L163	Name: High Performance Computing in Thermo-Fluid Applications	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Math III (PDE)			

Parallel computing for HPC: Historical perspective and introduction to High Performance Computing, Massively parallel computing using MPI and OpenMP, Different architectures and parallel programming models, Domain decomposition method, Message passing libraries, Communication between processors, Solution of hyperbolic and elliptic model problems using MPI, HPC Benchmarking & Performance analysis.

Construction of high accuracy & high efficiency methods for HPC: Spectral methods, Compact schemes and spectral optimization, Dispersion relation preservation property

(DRP) and analysis of DRP methods, Conjugate gradient methods, Numerical filters.
Grid generation methodologies for HPC applications in complex flows: Generalized coordinate transformation and grid generation methods, Chimera grid and role of interpolation error.
Some examples of HPC formulations for complex fluid flow: Bypass Transition, KH Instability, Separated flows past bluff bodies, Decaying Isotropic Turbulence in a periodic box

Text/Reference Books:

1. Sengupta T.K., *High accuracy computing methods: fluid flows and wave phenomena*, Tapan K., Cambridge Univ. Press.
2. Hoffmann K.A., and Chiang S.T., *Computational Fluid Dynamics (Vol. 1-3)*, Engineering Education System.
3. Aris R., *Vectors, Tensors and the Basic Equations of Fluid Mechanics*, Dover Publications.

Subject Code: ME6L164	Subject Name: Numerical Methods in Radiative Heat Transfer	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): None

Fundamentals of thermal radiation; Radiative transfer without participating media; Radiative transfer with participating media; Governing equations in radiative transfer analysis with participating media; Methods for solving radiative transfer problems - analytic method, Monte Carlo method, zonal method, flux method, P-N approximation, discrete ordinate method, finite element method, discrete transfer method, finite volume method, collapsed dimension method. Application of numerical methods for solving conjugate radiation, conduction and/or convection problems in 1-D and 2-D Cartesian and axi-symmetric geometry.

Text/Reference Books:

1. *Thermal Radiation Heat Transfer*, R. Siegel and J.R.Howell, Taylor & Francis, 2002.
2. *Radiation Heat Transfer*, E.M.Sparrow and R.D.Cess, Wadsworth, 1966.
3. *Radiative Transfer*, H.C.Hottel and A.F.Saroffim, McGraw hill, 1967.
4. *Radiative Heat Transfer*, M.F.Modest, McGraw Hill, 2003.

Subject Code: ME6L166	Name: Geophysical Fluid Dynamics	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): Fluid Mechanics

Introduction to geophysical fluid dynamics – rotation & stratification. Coriolis force. Equations of fluid motion (bulk flow & budgets, governing equations). Diffusion & transport process in oceans & atmosphere. Geostrophic flows & vorticity Dynamics. Ekman layer, barotropic waves & instability. Stratification & its effects, internal waves. Turbulence in stratified fluids. Introduction to stratified rotating flows – Quasi-Geostrophic dynamics, instabilities & geostrophic turbulence.

Text/Reference Books:

1. Gill A., *Atmosphere-Ocean Dynamics*, Academic Press.
2. Vallis G., *Atmospheric and Oceanic Fluid Dynamics*, Cambridge University Press.
3. Holton J., *An Introduction to Dynamical Meteorology*, Academic Press.
4. Pedlosky J., *Geophysical Fluid Dynamics*, Springer.

Subject Code: ME6L167	Subject Name: Design of Heat Exchangers	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Heat Transfer			

Introduction: Types, Classification of heat exchangers; Basic design methods for Heat Exchangers, Forced convection correlations, pressure drop, fouling in heat exchangers; Double pipe heat exchangers: Thermal and Hydraulic design; Fundamentals of two phase heat exchanger; Shell and Tube Heat exchangers: Basic design procedure, Kern method, Bell-Delaware method, Stream analysis method; Heat exchanger Network (HEN) and process integration; Pinch design method; Design of Compact Heat Exchangers; Thermodynamics of heat exchangers: Principles of Exergy analysis.

Text/Reference Books:

1. Sadik Kakac, H Liu, Heat Exchangers, Selection, Rating and Thermal Design, CRC Press, 2002.
2. R. K. Shah and D P Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons., 2003.
3. A. P. Fraas, Heat Exchanger Design, John Wiley & Sons, 1998
4. D.Q. Kern, Process heat Transfer, Tata McGraw-Hill Education, 2001
5. D. Butterworth, P.J. Heggs, W. Roetzel, Design and Operation of Heat Exchangers, Springer, 1992
6. Eric M. Smith, Advances in Thermal Design of Heat Exchangers: A Numerical Approach: Direct-sizing, Step-wise rating, and Transients, John Wiley, 2005
7. Spencer T. Branson, Heat Exchangers: Types, Design & Applications, Nova Science Pub Inc, 2011
8. T. Kuppan, Heat Exchanger Design Handbook, Taylor and Francis, 2000

Subject Code: ME6L168	Subject Name: Lattice Boltzmann Modeling	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Introduction; Kinetic theory and statistical mechanics – Chapman-Enskog procedure, Navier Stokes equation, BGK model; Lattice gas cellular automata; Lattice Boltzmann modeling; Thermal Lattice Boltzmann modeling; Boundary conditions; Multiple relaxation time model; Multiphase models – Pseudopotential model, Free energy model; Multicomponent models – Two color fluid method, Inumaro model, Hybrid LBM-FDM methods, Multigrid techniques, Applications of LBM.

Text/Reference Books:

1. S Succi, *The Lattice Boltzmann Model: For Fluid Dynamics and Beyond*, Oxford Univ. Press, 2001.
2. H Huang, M Sukop and Xi-Yun Lu, *Multiphase Lattice Boltzmann Methods: Theory and Applications*, Wiley Blackwell, 2015.
3. M Sukop and D Thorne, *Lattice Boltzmann Modeling: An Introduction for Geoscientists and Engineers,* Springer,-Verlag Berlin, 2007.
4. A A Mohamad, *Lattice Boltzmann Method: Fundamentals and Engineering Applications with Computer Codes,* Springer-Verlag London, 2011
5. H Farhat, J S Lee and S Kondaraju, *Accelerated Lattice Boltzmann Model for Colloidal Suspensions: Rheology and Interface Morphology*

Subject Code: ME6L169	Subject Name: Fluid Structure Interaction and Separated Flows	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Fluid Mechanics			

Examples of fluid structure interaction, Lagrangian & Eulerian description of kinematics, phenomenon of separation, theory of flow separation, main features of separated flows, vortices and vortex dynamics, instability and turbulence, drag and lift, active and passive techniques for flow control, interaction of separated flows with rigid and flexible structures, vortex induced vibrations, introduction to hydroelasticity theory, principal modes and natural frequencies, galloping and buffeting, damping of structures, sound induced by vortex shedding, energy harvesting.

Text/Reference Books:

1. H. J. Lugt, *Vortex flow in Nature and technology*.
2. Francois Axisa, ,Jose Antunes *Modelling of Mechanical Structures: Fluid Structure Interaction*.
3. Blevins, *Flow Induced Vibrations*, Krieger Publishing Co., Florida

Subject Code: ME6L170	Subject Name: Analytical Combustion	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Introduction to combustion and mass transfer, Thermodynamics of a pure substance and gaseous mixtures, Chemical equilibrium and Chemical kinetics, Derivation of transport equations, spontaneous ignition, Thermo-chemical reactors: Plug flow reactor, well-stirred reactor, constant mass reactor, Premixed flames, Diffusion flames, Combustion of particles and droplets.

Text/Reference Books:

1. A. W. Date, *Analytic Combustion, With Thermodynamics, Chemical Kinetics and Mass Transfer*, Cambridge Publication.
2. D. Brian Spalding, *Combustion and Mass Transfer A Textbook with Multiple-Choice Exercises for Engineering Students*, Elsevier Publication.

Subject Code: ME6L171	Subject Name: Mathematical Methods for Mechanical Engineers	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Initial Value Problems, Wave Equation, Heat Equation, Convection Equation, Conservation Laws, Navier-Stokes Equation, Finite Difference Methods: Accuracy and Stability, Lax Equivalence Theorem: CFL and Von Neumann Conditions, Fourier Analysis: Diffusion, Dissipation, Dispersion, Separation of Variables and Spectral Methods.

Solution of Large Linear Systems , Finite Differences, Finite Elements, Optimization, Direct Methods: Reordering by Minimum Degree, Iterative Methods and Preconditioning , Simple Iteration (Jacobi, Gauss-Seidel, Incomplete LU), Krylov Methods: Arnoldi Orthogonalization, Conjugate Gradients and GMRES, Multigrid Methods, Inverse Problems and Regularization

Text/Reference Books:

1. G. Strang, *Introduction to Linear Algebra*. 4th ed. Wellesley, MA: Wellesley-Cambridge Press.
2. Michael Woolfson & Malcolm S. Woolfson, *Mathematics for Physics,* Oxford Univ. Press.

Subject Code: ID 6LXXX	Name: **Design and Analysis of Experiments**	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s):

Introduction to Designed Experiments: Strategy of experimentation, Typical applications, Basic principles and guidelines for designing experiments, Basic statistical concepts: Descriptive Statistics, Sampling and Sampling Distributions, Tests of Hypotheses, Single factor experiments with Fixed Effects: ANOVA, Model Adequacy Tests, Orthogonal Contrasts, Experiments with Blocking Factors: Randomised Complete and Incomplete Block Designs, Latin Squares Design , Factorial Experiments: 22,, 32, and 2k Designs, Blocking and Confounding, and Fractional Factorial Designs , Linear Regression Models: Estimation of Parameters, Tests of Hypothesis, Regression Model Diagnostics, Response Surface Design: Method of Steepest Ascent, Second-Order Response Surface, Experimental Designs, Computer Models, Mixture Experiments, Evolutionary Operations, Advanced Design of Experiments: Random Effects Models, Analysis of Covariance, Non-Normal Response, and Taguchi Methods.

Recommended Books:

1. *Design and Analysis of Experiments*, D. C. Montgomery, John Wiley & Sons, Wiley Student Edition, International Student Version, 7th Edition.
2. *Experimental Design: From User Studies to Psychophysics,* D. W. Cunningham and C. Wallraven, CRC Press.
3. *Design of Experiments: An Introduction Based on Linear Models*, M. Morris, Chapman & Hall/CRC Texts in Statistical Science, First Edition.
4. *Experiments: Planning, Analysis, and Optimization* C. F. J. Wu and M. S. Hamada, Wiley Series in Probability and Statistics, Wiley.
5. *Statistics for Experimenters: Design, Innovation, and Discovery*, G. E. P. Box, J. S. Hunter, and W. G. Hunter, Wiley, 2nd Edition.
6. *Practical Guide to Designed Experiments: A Unified Approach*, P. D. Funkenbusch, CRC Press.
7. *Statistical Design and Analysis of Experiments, with Applications to Engineering and Science,* R. L. Mason, R. F. Gunst, and J. L. Hess, Wiley Interscience, Second Edition.
8. *Design and Analysis of Experiments* A. M. Dean and D. Voss, Springer Texts in Statistics, Second Edition.
9. *The Theory of the Design of Experiments,* D. R. Cox and N. Reid, Chapman and Hall/CRC.
10. *Statistical Design and Analysis of Experiments*, P. W. M. John, (Classics in Applied Mathematics No 22), Society for Industrial and Applied Mathematics.

Elective – IV (Semester IX)

Subject Code: ME6L001	Subject Name: Vibrations	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): Theory of Machines II			

Fundamental concepts in vibration and modeling: Introduction to modeling and analysis Introduction to mechanical vibration
Free vibration of single degree of freedom systems: Undamped vibration; Simple harmonic motion; Damped vibration; Modeling: Energy and Newton's methods; Measurement of vibrational components; Design Consideration; Stability
Forced harmonic excitation of single degree of freedom systems: Undamped vibration; Damped vibration; Base excitation; Rotating unbalance; Coulomb damping
Vibration of single degree of freedom systems under general forcing conditions: Impulsive inputs; Arbitrary nonperiodic inputs; Arbitrary periodic inputs; Stability
Vibration of multi degree of freedom systems: Modeling, Free undamped vibration; Eigenvalue problem; Modal analysis; Free damped vibration; Forced vibration Dynamic vibration absorbers; Isolators for shock and harmonic loading.

Text/Reference Books:

1. Thomson W.T., and Dahleh M.D., *Theory of Vibrations with Applications,* Pearson Education.
2. Palm W.J., *Mechanical Vibration*, Wiley Publishers.
3. Tongue B.H., *Principles of Vibration*, Oxford University Press.
4. Meirovitch L., *Fundamentals of Vibrations*, Mcgraw-Hill.
5. Kelly G.S., *Mechanical Vibrations: Theory and Applications,* CL-Engineering Publication.
6. Rao S.S., *Mechanical Vibration,* Prentice Hall.
7. Rao J.S., *Advanced Theory of Vibration*, New Age International.
8. Mukhopadhyay M., *Structural Dynamics: Vibrations and Systems*, ANE Books.
9. McConnell K.G., and Varoto P.S., *Vibration Testing: Theory and Practice,* Wiley.
10. Timoshenko S., *Vibration problems in engineering*, Oxford University Press.

Subject Code: ME6L009	Subject Name: Engineering Measurements	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Principles of Measurement: Static characteristics and accuracy in the steady state, Generalized model, Measurement errors and error reduction techniques, Dynamic characteristics, Loading effects and noise, Transfer function, TiMEnd frequency responses, Dynamic errors and compensation, Random signals and effects of noise and interference, Noise sources and reduction methods, Economics of measurement systems: Reliability, Selection of measurement systems, Operating cost; Measurement System Design: Sensing elements: resistive, capacitive, inductive, electromagnetic and other sensing elements, Signal conditioning and processing elements: deflection bridges, amplifiers, AC carrier systems, current transmitters, oscillators and resonators, A/D conversion, sampling, quantization and encoding, Data Acquisition, Multiplexing, Data acquisition system, digital signal analysis; Specialized Measurement Systems: Principles of flow, optical and ultrasonic measurement systems, Heat transfer effects and particle size analysis.

Text/Reference Books:

1. Figliola R.S., and Beasley D.E., *Theory and Design for Mechanical Measurements*, John Wiley & Sons.
2. Beckwith T.G., Marangoni R.D., and Lienhard J.H., *Mechanical Measurements*, Pearson.
3. Nakra B.C., and Chaudhry K.K., *Instrumentation: Measurement and Analysis*, Tata Mcgraw-hill Education Private Ltd.

Subject Code: ME6L010	Subject Name: Operations Management	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): None

Productivity, Competitiveness, Production Systems, Operations Strategy, Balance Scorecard, Facility Location, Decision Analysis, Facility Layout, Product and Services, Quality Function Deployment, Process Planning, Process Selection, Quality Control, Inventory Control, Inventory Models, Lean Production System, Project Management, Work Design and Measurement, Resource Planning, Scheduling, Forecasting Methods.

Text/Reference Books:

1. Russel, and Taylor, *Operations management*, Wiley India.
2. Krajewski, Ritzman, and Malhotra, *Operations management*, Pearson Prenctice Hall.
3. Heizer, and Render, *Operations management*, Pearson Education.
4. Stevenson, *Operations Management*, McGraw Hill.
5. Chase and Aquilano, *Operations Management*, Tata McGraw Hill.

Subject Code: ME6L011	Subject Name: Finite Element Methods in Engineering	L-T-P: 3-1-0	Credit: 4

Pre-Requisite(s): Math IV (PDE)

Introduction. Integral Formulations and Variational Methods.

FE Analysis of One-dimensional problems. Second-Ordesr boundary value problems; Bending of Beams; FE Error Analysis; Eigenvalue and Time-Dependent Problems; Numerical Integration and Computer Implementation.

FE Analysis of Two-Dimensional Problems. Single-Variable Problems; Interpolation Functions, Numerical Integration and Modeling; Plane Elasticity; Flows of Viscous Incompressible Fluids; Bending of Elastic Plates; Computer Implementation.

FE Analysis of Three-Dimensional and Nonlinear Problems.

Text/Reference Books:

1. Reddy J.N., *An Introduction to the Finite Element Method*, McGraw Hill.
2. Reddy J.N., *An Introduction to Nonlinear Finite Element Method*, Oxford University Press.
3. Cook R.D., *Concepts and Applications of Finite Element Analysis,* Willey.
4. Zienkiewicz O.C., *The Finite Element Method: Its Basis & Fundamental,* Elsevier.
5. Rao, *The Finite Element Method in Engineering*, Elsevier.
6. Dixit U.S., *Finite Element Methods for Engineers*, Cengage Publications.
7. Chandrupatla T.R., *Introduction to Finite Elements in Engineering*, PHI.

Subject Code: ME6L014	Subject Name: Introduction to Nonlinear Dynamics	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): None

A brief introduction to modelling. One dimensional flows: Flows on the line : Geometrical intuition, Fixed points and stability, Local stability analysis, Existence and uniqueness, Impossibility of oscillations, Potentials Solving equations on the computer, Bifurcations: Saddle-node, Normal forms, Transcritical, Pitchfork Imperfect bifurcations, Numerics (XPP-Auto), Flows on the circle: Uniform oscillator, Non-uniform oscillator. Two dimensional flows: Linear systems: Definitions and examples, Classification of linear systems, Dynamics of love affairs, Phase plane: Phase portraits, Existence, uniqueness and

topological consequences, Fixed points and linearization, Example: population dynamics, Limit cycles: Ruling out closed orbits, Poincare-Bendixson theorem, Lienard systems, Weakly nonlinear oscillators, Bifurcations: Saddle-node, Transcritical and Pitchfork, Choice of bifurcation parameter, Hopf Poincare maps. Final comments: Higher-order systems, and the existence of chaos, Importance of time delays and noise

Text/Reference Books:

1. Steven Strogatz, *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering* by Perseus Books.
2. M Lakshmanan, *Nonlinear Dynamics: Integrability, Chaos and Patterns*, Springer (India) Pvt. Ltd.
3. Marco Thiel, Jürgen Kurths , M. Carmen Romano , György Károlyi , Alessandro Moura, *Nonlinear Dynamics and Chaos: Advances and Perspectives (Understanding Complex Systems)*, Springer.

Subject Code: ME6L104	**Subject Name: Conduction & Radiation Heat Transfer**	**L-T-P: 3-0-0**	**Credit: 3**

Pre-Requisite(s): Fluid Mechanics, Heat Transfer

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. Transient heat conduction, conduction with moving boundary, solidification and melting. Problems with periodic boundary conditions. Fundamentals of thermal radiation; integral equation for radiative exchange; view factors. Radiative exchange between surfaces: black surfaces, gray, diffuse, partially specular surfaces. 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.

Text/Reference Books:

1. Poulikakos D., *Conduction Heat Transfer*, Prentice Hall.
2. Kakac S., and Yener y., *Heat Conduction*, Taylor and Francis.
3. Myers G.E., *Analytical methods in Conduction Heat Transfer*, McGraw Hill.
4. Arpaci V.S., *Conduction Heat Transfer*, Abridged edition Ginn press.
5. Chapman A.J., *Heat Transfer*, Macmillan.
6. Siegel R., and Howell J.R., *Thermal Radiation Heat Transfer*, Taylor & Francis.
7. Sparrow E.M., and Cess R.D., *Radiation Heat Transfer*, Wadsworth.
8. Hottel H.C., and Saroffim A.F., *Radiative Transfer*, McGraw hill.
9. Modest M.F., *Radiative Heat Transfer*, McGraw Hill.

Subject Code: ME6L107	**Subject Name: Air-Conditioning & Ventilation**	**L-T-P: 3-0-0**	**Credit: 3**

Pre-Requisite(s): Thermodynamics

Psychrometry, simple psychometrics processes, use of psychometrics chart. Comfort and industrial air conditioning. Air filtration. Principles of ventilation. Physiological factors. Comfort index. Air conditioning systems: Spray systems, chilled water and DE Coils, absorption and adsorption systems. Humidifiers. Air conveying: fans, ducts and air diffusion equipment. Estimation of air conditioning load, determination of supply state. Design and constructional details of Unitary air conditioning equipment. Noise level and acoustic control. Automatic controls in air conditioning.

Text/Reference Books:

1. Jones W.P., *Air Conditioning*, Butterworth Heinemann Publishers.
2. Ameen A., *Refrigeration and Air Conditioning*, PHI.

3. Stocker W.F., and Jones J.W., *Refrigeration and Air Conditioning*, McGraw-Hill Publishing Company.
4. Arora C.P., *Refrigeration and Air Conditioning*, McGraw-Hill.
5. Rajput R.K., *Refrigeration and Air Conditioning*, S. K. Kataria & Sons.

Subject Code: ME6L112	**Subject Name: Two Phase Flow Heat Transfer**	**L-T-P: 3-0-0**	**Credit: 3**
Pre-Requisite(s): None			

Formulation and Solution to Phase Change Problem, Two Phase Flow Fundamentals, Review of one-dimensional conservation equations in single phase flows; Governing equations for homogeneous, separated and drift-flux models; Flow pattern maps for horizontal and vertical systems; Simplified treatment of stratified, bubbly, slug and annular flows. Modelling of Two-Phase Flow, Pressure Drop in Two-Phase Flow, Brief Discussion on Critical Flow and Unsteady Flow.

Description and Classification of Boiling, Pool Boiling Curve, Nucleation and Dynamics of Single Bubbles, Heat Transfer Mechanisms in Nucleate Boiling, Nucleate Boiling Correlations, Hydrodynamic of Pool Boiling Process, Pool Boiling Crisis, Film Boiling Fundamentals, Flow Boiling, Forced-Flow Boiling Regimes, Flow Boiling Curves, Nucleate Boiling in Flow, Sub-cooled Nucleate Flow Boiling, Saturated Nucleate Flow Boiling, Flow Boiling Correlations, Flow Boiling Crisis. Condensation- Film and dropwise condensation.

Text/Reference Books:

1. S. Mostafa Ghiaasiaan, "*Two-Phase Flow, Boiling And Condensation in Conventional and Miniature Systems*", Cambridge University Press, 2008
2. L. S. Tong and Y. S. Tang, "*Boiling Heat Transfer and Two-Phase Flow*", Taylor and Francis, 1997
3. J. B. Collier, and J. R. Thome, "*Convective boiling and condensation, Oxford Science Publications*", 1994.

Subject Code: ME6L113	**Name: Spectral Methods for Engineering & Scientific Computing Applications**	**L-T-P: 3-0-0**	**Credit: 3**
Pre-Requisite(s):			

Introduction: What are Spectral methods? Basic ideas, survey of applications. Fundamentals: Projection, Fourier Galerkin, and Spectral Convergence. Interpolation, Fourier Collocation. Approximation of Derivatives. Aliasing error, convergence of interpolation and collocation. Variable coefficients and nonlinear problems (mode coupling, aliasing, aliasing removal, filtering). Sturm-Liouville problems, polynomial truncation and interpolation. Spectral approximations: CG, Collocation, tau, Penalty, DG. Elliptic problems, Laplacian Solver, Poisson solver. Advection-diffusion problems, CG approximation. Solving Laplace/Poisson Equation on a Square using Spectral Approximations: Fourier, CG etc. Hyperbolic conservation laws, DG approximation, Euler gas dynamics equations. Solutions for Advection-Diffusion Problems using CG Approximation. Advection-Diffusion and Compressible Navier-Stokes, DG approximation. Solution of Advection-Diffusion Equation using DG Approximation. Introduction to Spectral Element Method: CG and DG Spectral elements in 1D. CG and DG in 2/3D on structured meshes. Spectral Element Methods on unstructured meshes. Issues and approaches for solution of general problems.

Text/Reference Books:

1. D.A. Kopriva, *Implementing Spectral Methods: Algorithms for Scientists and Engineers*, Springer, 2009.
2. C. Canuto, M.Y. Hussaini, A. Quarteroni and T.A. Zang, *Spectral Methods: Fundamentals in Single Domains*, Springer 2007.
3. C. Canuto, M.Y. Hussaini, A. Quarteroni and T.A. Zang, *Spectral Methods: Evolution to Complex Geometries and Applications to Fluid Dynamics*, Springer 2010.

Subject Code: ME6L114	Subject Name: Solar Energy	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Fluid Mechanics, Heat Transfer			

Introduction to energy systems, Review of renewable energy sources, Solar Hot Water system – construction of a solar hot water system, Fundamentals of solar – solar radiation, structure of the Sun PV panels, modules, arrays and characteristics – physics of the solar cell, types of solar cells, PV solar panel, Solar modules, Solar arrays, Photovoltaic system construction and MPP tracking – standalone system, grid – tied system, sizing a solar system, Inverters – true sine wave, modified sine wave, Battery types – characteristics, limitation, installation, sizing.

Text/Reference Books:

1. S P Sukhatme and J K Nayak, *Solar Energy*, McGraw Hill Education (India) Private Limited, 3rd edition.
2. G N Tiwari, *Solar Energy: Fundamentals*, Design, Modelling and Application (Revised Edition), Narosa Publishing House Pvt. Ltd.

Subject Code: ME6L117	Name: Introduction to Atmospheric Radiation	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Radiative transfer, definition and quantities, Radiative transfer equation, RTE for plane parallel atmosphere, two stream method, Eddington method for multi layer atmosphere, Doubling method, Discrete ordinates method, Reflection and Absorption by a layer of the Atmosphere – Absorption and Emission of Infrared Radiation in Cloud-Free Atmosphere. Polarization, Reflection of an interface, Dielectric property of surface and atmospheric constituents, Scattering of radiation by molecules and particles – Rayleigh and Mie scattering, Community model solutions to RTE, Passive remote sensing of precipitation, Inverse techniques using RTE.

Text/Reference Books:

1. Chandrasekar S, *Radiative Tranfer*, Dover
2. Grand W. Petty, *A first course in Atmospheric Radiation*, Second Edition, Sundog Publishing, Madison, Wisconsin.
3. Liou, K.N, *An Introduction to Atmospheric Radiation*, Second Edition, Academic Press.
4. John M. Wallace and Peter V Hobbs, *Atmospheric Science – An Introductory Survey*, Second Edition, Elsevier publications.

Subject Code: ME6L118	Name: Statistical Thermodynamics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

The molecular interpretation of thermodynamic equilibrium. Development of the partition function. Introduction to quantum mechanics and molecular spectroscopy. The Maxwell-Boltzmann formulation of statistical mechanics and applications to ideal gases, solids, radiation, and laser diagnostics. The Gibbs formulation of statistical mechanics and application to real gases. Kinetic theory and applications to transport properties and chemical kinetics.

Text/Reference Books:

1. Normand M. Laurendeau, *Statistical Thermodynamics: Fundamentals and Applications,* 1st Edition, Cambridge Press, 2005.
2. Van P. Carey, *Statistical Thermodynamics and Microscale Heat Transfer,* Cambridge Univ. Press, 1999
3. D Chandler, *Introduction to Modern Statistical Mechanics,* Oxford Univ. Press, 1987
4. T L Hill, *An Introduction to Statistical Thermodynamics,* Dover Publications, 1986

Subject Code: ME6L119	Name: Micro / Nano Scale Heat Transfer	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Heat and Mass Transfer			

Introduction to micro/nano scale transport phenomena, Material waves and energy quantization, Energy states in Solids, Statistical Thermodynamics and Thermal Energy Storage, Energy Transfer by waves, Particle description of transport process: Classical laws, Boltzmann transport equation, Classical size effects, Energy conversion and couple transport process, Coupled nonequilibrium electron-phonon transport, Applications of micro/nanoscale heat transfer - nanoparticles and nanofluids, Thermoelectric devices, Short pulse laser heating of metals, microheat pipes, microelectronics, superconducting films.

Text/Reference Books:

1. *Nanoscale Energy Transfer and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons,* by G Chen, Oxford Press, 2005
2. *Nano/Microscale Heat Transfer, 1st Edition,* by Z Zhang, Mcgraw Hill, 2007
3. *Microscale and Nanoscale Heat Transfer: Fundamentals and Applications, 1st Edition*, by C B Sobhan and G P Peterson, CRC Press Taylor and Francis Group, 2008
4. *Microscale and Nanoscale Heat Transfer, Sebastian Volz (Ed.),* Springer-Verlag Berlin, 2005
5. *Statistical Thermodynamics and Microscale Heat Transfer*, Van P. Carey, Cambridge Univ. Press, 1999

Subject Code: ME6L120	Name: Applications of Linear Algebra in Mechanical Engineering	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Key Ideas of Linear Algebra, Differential Eqns. and Difference Eqns., Solving a Linear System, Eigenvalues and Positive Definite matrix, Springs and Masses, Oscillation, Finite Differences in Time, Least Squares, Graphs and Networks, Kirchhoff's Current Law, Trusses, Finite Elements in 1D, Quadratic/Cubic Elements, Element Matrices; 4th Order Bending Equations, Boundary Conditions, Splines, Gradient, Divergence, Gradient and Divergence, Laplace's Equation, Finite Elements in 2D, Fast Poisson Solver, Fourier Series, Discrete Fourier Series, Fast Fourier Transform, Convolution, Filtering, Fourier Integral Transform, Convolution Equations: Deconvolution, Sampling Theorem

Text/Reference Books:

1. G. Strang, *Introduction to Linear Algebra*. 4th ed. Wellesley, MA: Wellesley-Cambridge Press.
2. Michael Woolfson & Malcolm S. Woolfson, *Mathematics for Physics,* Oxford Univ. Press.

Subject Code: ID6LXXX	Name: Data Analytics	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

The syllabus spans the development of data analytics in the fields of statistics, management science, data mining, and machine learning. The subject will involve hands-on experience with statistical software packages, Sources, modes of availability, inaccuracies, and uses of data, Descriptive Statistics; Visualization; and Data Similarity and Dissimilarity, Cleaning for Missing and Noisy Data; Data Reduction – Discrete Wavelet Transform, Principal Component Analysis, Partial Least Square Method, Attribute Subset Selection; and Data Transformation and Discretization, Probability Density Functions; Inferential Statistics through Hypothesis Tests, Predictive Analysis (Regression and Correlation, Logistic Regression, In-Sample and Out-of-Sample Predictions), Prescriptive Analytics (Optimization and Simulation with Multiple Objectives); Concepts of Support and Confidence; Frequent Itemset Mining Methods; Pattern Evaluation, Decision Trees – Attribute Selection Measures and Tree Pruning; Bayesian and Rule-based Classification; Model Evaluation and Selection; Cross-Validation; Classification Accuracy; Bayesian Belief Networks; Classification by Backpropagation; and Support Vector Machine, Partitioning Methods – k-means Hierarchical Methods and Hierarchical Clustering Using Feature Trees; Probabilistic Hierarchical Clustering; Introduction to Density-, Grid-, and Fuzzy and Probabilistic Model-based Clustering Methods; and Evaluation of Clustering Methods., Ridge Regression; Lasso Regression; and k-Nearest Neighbours, Regression and Classification, Bias-Variance Dichotomy, Linear and Quadratic Discriminant Analysis, Classification and Regression Trees, Ensemble Methods: Random Forest, Neural Networks, Deep Learning.

Text/Reference Books:

1. Han, J., M. Kamber, and J. Pei, Data Mining: Concepts and Techniques, Elsevier, Amsterdam. Textbook.
2. James, G., D. Witten, T. Hastie, and R. Tibshirani, An Introduction to Statistical learning with Application to R, Springer, New York.
3. Jank, W., Business Analytics for Managers, Springer, New York.
4. Williams, G., Data mining with Rattle and R: The Art of Excavating Data for Knowledge Discovery, Springer, New York.
5. Witten, I. H., E. Frank, and M. A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann.
6. Wolfgang, J., Business Analytics for Managers, Springer.
7. Montgomery, D. C., and G. C. Runger, Applied Statistics and Probability for Engineers. John Wiley & Sons.
8. Samueli G., N. R. Patel, and P. C. Bruce, Data Mining for Business Intelligence, John Wiley & Sons, New York.
9. Hastie, T., R. T. Jerome, and H. Friedman, The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer.
10. Bishop C., Pattern Recognition and Machine Learning, Springer.
11. Tan, P., M. Steinbach, and V. Kumar, Introduction to Data Mining, Addison-Wesley.

Laboratory Courses (Semester I – VI)

Subject Code: PH1P001	Subject Name: Physics Laboratory	L-T-P: 0-0-3	Credit: 2

Pre-Requisite(s): None

1. To determine the damping constant of the pendulum for different eddy damping current.
2. To verify Malus's Law of polarization of light.
3. To determine the wave length of the prominent lines of mercury source by a plane transmission diffraction grating and to calculate the resolving power and dispersive power of the grating.
4. To study the intensity distribution of Fraunhofer diffraction pattern by a single slit and measure the width of the slit for a given wavelength of laser light.
5. To determine the wavelength of the given source using the Michelson interferometer.
6. To determine the wave length of the given source using Fresnel's biprism.
7. To find out the resonance and beat time period of the coupled pendulum and find out the spring constant.
8. To study the interference pattern and determine the radius of curvature of the plano convex lens using Newton's rings apparatus.

Text/Reference Books:

1. Ghatak *A. Optics*, McGraw-Hill.
2. Pain H. J. *The Physics of Vibrations and Waves*, Wiley.

Subject Code: CY1P001	Subject Name: Chemistry Laboratory	L-T-P: 0-0-3	Credit: 2

Prerequisite(s): None

Experiment-1: Determination of the surface tension and parachor of a homologous series.

Experiment -2: Measurement of the coefficient of viscosity of ethanol & ethanol -water system.

Experiment -3: Studies on acid-base conductometric titration.

Experiment- 4: Studies on PH metric titration of strong base with strong acid.

Experiment -5: Estimation of sulphate ion in tap water by nepheloturbidimetric analysis.

Experiment - 6: Spectrophotometric determination of acid dissociation constant (pka) of methyl red (MR) an acid base indicator.

Experiment -7: Determination of solubility and solubility product of a sparingly soluble salt at room temperature by conductometric method.

Experiment- 8: Potentiometric titration of a given sodium carbonate solution with aquesous hydrochloric acid solution.

Experiment -9: kinetics of ester hydrolysis.

Experiment -10: Detection of functional groups in an organic compound for solid sample.

Experiment-11: Detection of functional groups in an organic compound for liquid sample.

Experiment -12: Thin layer chromatography (TLC).

Text/Reference Books:

1. Nad, A. K.; Mahapatra, B. and Ghoshal A. *An advanced course in practical chemistry*, New Central Book Agency (P) Ltd.
2. Elias A. J. *A collection of general chemistry experiments*, University Press.

Maity S. and Ghosh N. *Physical Chemistry Practical*, New Central Book Agency (P) Ltd.

Subject Code: EE1P001	Subject Name: Electrical Technology Laboratory	L-T-P: 0-0-3	Credits: 2
Prerequisite(s): Electrical Technology			

Experiments as per the topics in the syllabus for the course `Electrical Technology' (EE1L001) will be conducted in the laboratory class.

Text Books:

1. E. Hughes, *"Electrical Technology,"* Pearson Education, 2010.
2. V. Del Toro, "Electrical Engg Fundamentals," PHI Learning, 2009.

Reference Books:

1. I. J. Nagrath and D. P. Kothari, *'Basic Electrical Engineering'* TATA McGraw Hill Education, 2009.
2. D. A. Bell, *"Electric Circuits,"* 7th Ed., Oxford Higher Education, 2009.

Subject Code: CS1P001	Subject Name: Introduction to Programming and Data Structures Laboratory	L-T-P: 0-0-3	Credit: 2
Prerequisite(s): Introduction to Programing and Data Structures			

Familiarization of a computer and the environment; Execution of sample programs related to Expression evaluation, Conditionals and branching, Iteration, Functions, Recursion, Tail-recursion, Arrays, String manipulation, Structures, Linked lists, Doubly-linked lists and Binary Trees. Execution of programs involving abstract data types like Stacks and Queues.

Subject Code: CE1P001	Subject Name: Engineering Drawing	L-T-P: 1-0-3	Credit: 3
Pre-requisite(s): None			

Introduction to IS code of drawing; Conics and Engineering Curves – ellipse, parabola, hyperbola, cycloid, trochoid, involute; Projection of lines – traces, true length; Projection of planes and solids; sold objects – cube, prism, pyramid, cylinder, cone and sphere; Projection on Auxiliary planes; Isometric projection, isometric scale; Section of solids – true shape of section; Introduction to CAD tools – basics; Introduction of Development and Intersection of surfaces.

Text/Reference Books:

1. Bhatt N.D.*Elementary Engineering Drawing*, Charotar Publishing House.
2. Gill P.S.*Engineering Drawing & Engg. Graphics*, S. K. Kataria & Sons.
3. Lakshminarayan L.V. and Vaish R.S.*Engineering Graphics*, Jain Brothers.

Subject Code: ME1P001	Name: Introduction to Manufacturing Processes	L-T-P: 0-0-3	Credit: 2
Pre-requisite(s): None			

Machining:

- Introducing to various machine tools and demonstration on machining
- Making a steel pin as per drawing by machining in centre lathe
- External screw thread on lathe
- Making a cast iron Vee block by shaping
- Making a regular polygon prism (MS)/ hexagon by milling machine
- Slot fitting by milling machine
- Study of machining in machining in machining centre (CNC)
- Study of Electro discharge machining (EDM)

Foundry Practice:

- Orientation, demonstration and practice on metal casting
- Practicing sand moulding using split and uneven parting line pattern
- Practice on CO2 moulding and machine moulding
- Mechanised sand preparation and melting practice

Welding Practice:

- Practice on electric arc welding
- Practice on oxy-acetylene gas welding
- Introduction and demonstration on submerged arc welding

Metal Forming:

Demonstration of deep drawing and other forming process

Text/Reference Books:

1. Chapman W.A.J., *Workshop Technology - Part I*, CBS Publishers.
2. Chapman W.A.J., *Workshop Technology - Part II*, CBS Publishers.
3. Hajra Choudhury S.K., *Elements of workshop Technology Vol. I*, Media Promoters.
4. Hajra Choudhury S.K., *Elements of workshop Technology Vol. II*, Media Promoters.

Subject Code: ME2P001	**Name: Workshop Processes**	**L-T-P: 0-0-3**	**Credit: 2**

Prerequisite(s): None

Turning: facing, drilling, boring, turning-straight, taper, eccentric, grooving, thread cutting, forming etc. in centre lathes.

Milling: surfacing, making regular polygons and cutting gear teeth in milling machines.
Hobbing: gear teeth generation in gear shaping machine and hobbing machine.

CNC Machining: 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.

Text/Reference Books:

- Rao P.N., *Manufacturing Technology*, Tata McGraw – Hill.
- Jain R.K., *Production Technology*, Khanna Publishers.
- Lindberg, Process and materials of manufacturing, Prentice-Hall.
- Heine R.W., Loper C.L., and Rosenthal P.C., *Principles of Metal Castings*, Tata McGraw – Hill.

Subject Code: ME2P002	**Name: Fluid Mechanics Lab**	**L-T-P:0-0-3**	**Credit: 2**

Prerequisite(s): None

Hydrostatic Pressure & Measurement of Pressure; Center of Pressure on a Submerged Plane Surface; Impact of a Jet of Water; Laminar & Turbulent Flow in Pipes; Minor & Major Losses in Pipe Flow; Measurement of Flow Rates; Pressure Distribution About a Circular Cylinder, Drag Force Determination; External Laminar Flows Over Immersed Bodies; Laminar & Turbulent Boundary Layer.

Subject Code: ME2P003	**Name: Machines & Mechanisms Laboratory**	**L-T-P: 0-0-3**	**Credit: 2**

Prerequisite(s): None

Four Bar Link Mechanism, Single Stage Helical Gear, Oldham's Coupling, Single Stage Spur Gear with Intermediate gear, Differential Gear, Universal Joint-Single and Double joint, Epicyclic Gear with Three Gears, Reciprocating Engine Mechanism, Oscillating Cylinder Mechanism, Sun-Planet Annular gear, Three Stage Spur Gear, Whitworth Quick Return Mechanism, ScotchYoke Mechanism, Worm Gear, Single Stage Spur Gear(Parallel Axis), Bevel Gear(Single).

Subject Code: ME2P004	Name: Materials Testing Laboratory	L-T-P: 0-0-3	Credit: 2
Prerequisite(s): None			
Tests using UTM (Tensile test, Three point bend test, compression test etc.; Hardness tests; Impact test; Fatigue test (Rotary and Axial); Torsion test; Cupping test; Spring compression test; Stresses in pressure vessels; Introduction to Photoelasticity; Strain measurements using strain gauges.			
Subject Code: ME3P001	**Name: Thermo-Fluid Lab - 1**	**L-T-P: 0-0-3**	**Credit: 2**
Prerequisite(s): None			
Linear and radial heat conduction, Heat transfer through extended surfaces, Determination of heat transfer coefficient in free and forced convection, Experiments to verify various radiation heat transfer laws, Parallel and counter flow heat exchangers: LMTD and temperature distribution, Radiation error in temperature measurement.			
Subject Code: ME3P002	**Name: Casting, Welding and Forming Laboratory**	**L-T-P: 0-0-3**	**Credit: 2**
Prerequisite(s): None			
Casting: Practice on CAD of gating and riser, 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. **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. **Forming**: Experiments on formability test, powder compaction; strip layout for progressive die design.			
Subject Code: ME3P003	**Name: Machine Design Practice**	**L-T-P: 0-0-3**	**Credit: 2**
Prerequisite(s): None			
Design and Drawing of Simple Machine Elements; Assembly Drawings; Use of CAD softwares that allows development of three-dimensional (3-D) designs; Introduction and Application of Engineering based softwares for Mechanical Engineering Applications.			
Subject Code: ME3P004	**Name: Thermo-Fluid Lab - 2**	**L-T-P: 0-0-3**	**Credit: 2**
Prerequisite(s): None			
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. 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.			
Subject Code: ME3P005	**Name: MTM Laboratory**	**L-T-P: 0-0-3**	**Credit: 2**
Prerequisite(s): None			
Machine tools: 1. Acceptance test of machine tool (radial drilling machine) 2. System compliance of machine tool (center lathe). **Machining**: 3. Resharpening of turning tool to specific geometry 4. Measurement of cutting forces and surface finish in turning, drilling and milling 5. Measurement of cutting temperature and tool life in turning 6.			

Measurement of grinding forces and surface finish in grinding 7. Machine setting and operation for helical gear teeth cutting**. Metrology**: 8. Inspection of straightness and flatness of surfaces Measurement of angles 9. Measurement of external and internal taper 10. Inspection of screw threads 11. Inspection of gear teeth 12. Measurement of roundness by Telerond Calibration of measuring instruments.