Detailed Syllabus for B. Tech Degree Programme
in
Mechanical Engineering

(Effective from 2017 Admitted Batch onwards)

Semester III							
Sl No	**Code**	**Subject**	**L**	**T**	**P**	**Credit**	**Category**
1	MA 13101	Mathematics III	3	1	0	4	BS
2	ME 13101	Mechanics of Fluids	3	1	0	4	DCS
3	ME 13102	Elements of Solid Mechanics	3	1	0	4	DCS
4	ME 13103	Thermodynamics	3	1	0	4	DCS
5	ME 13104	Materials Science and Metallurgy	3	0	0	3	DCS
6	ME 13105	Electrical Measurements and Machines	3	0	0	3	BES
7	ME 13201	Machine Drawing	0	0	3	2	DCS
8	EE 13202	Electrical Measurements and Machines Laboratory	0	0	3	2	BES
Total			18	4	6	26	

SEMESTER III

Course Code: ME 13101 **L-T-P-C**
Course Title: MECHANICS OF FLUIDS **3-1-0-4**
Pre-requisite: NIL
Course content
Module 1 (10 hours)
Basic Concepts, Fluid Statics and Fluid Kinematics, Fluid dynamics - concept of the control volume -Reynolds transport equation and its use to formulate fluid mechanics problems, Integral and differential forms of the continuity - momentum equations, Illustrative examples for the conservation of mass, linear and angular momentum

Module 2 (18 hours)
Non viscous equation for the flow through a stream tube and along a stream line – Euler‗s equation – Bernoulli‗s equation, - Applications of the one dimensional equations - velocity and flow measurement and quasi steady problems, Laminar and turbulent flow through pipes - Hagen- Poiseuille equation - Darcy-Weisbach equation - pipe friction - Moody‗s chart - minor losses in pipes.

Module 3 (18 hours)
Two dimensional incompressible inviscid flows – Vorticity - Irrotational flow - Velocity potential, Stream function - relation between stream function and potential function in ideal flows -Equation of a streamline - governing equations, Fundamental flow patterns, Combination of basic patterns - Rankine half body - Rankine oval - Doublet and flow past a cylinder, Magnus effect and the calculation of lift on bodies.

Module 4 (10 hours)
Viscous flow, Derivation of Navier Stokes Equation, The boundary layer - Prandtl‗s boundary layer equations, Blasius solution for the boundary layer over a flat plate, Karman‗s Momentum Integral equations - Solutions using simple profiles for the boundary layer on flat plate - calculation of skin friction drag.

Reference

1. Shames, I.H., ‗*Mechanics of fluids'*, Mc Graw Hill Book Co., 1986.
2. White, F.M., ‗*Fluid Mechanics'*, 6th Ed., Tata Mc Graw Hill, New Delhi, 2009.
3. Cengel, Y.A, Cimbala, John, M., ‗*Fluid Mechanics, Fundamentals and Applications'*, 7th Ed. Tata Mc Graw Hill, New Delhi, 2009.
4. Gupta, V., Gupta, S.K.., ‗*Fluid Mechanics and its applications'*, New Age International, New Delhi, 2005.
5. 5.Som, S.K., and Biswas, G., ‗*Fluid Mechanics and fluid Machines'*, 2nd Ed., Tata Mc Graw Hill, New Delhi, 2005.
6. Som, S.K., and Biswas, G.,Chakraborty. S., Introduction to f*luid Mechanics and fluid Machines'*, 3rd Ed., Tata Mc Graw Hill, New Delhi, 2017

Course Code: ME 13102 **L-T-P-C**
Course Title: ELEMENTS OF SOLID MECHANICS **3-1-0-4**
Pre-requisite: NIL
Course Content

Module 1 (16 hours)
Introduction, general concepts – definition of stress – stress tensor, Stress analysis of axially loaded members, shear stresses – direct shear problems, Strength based design of members (deterministic method), Axial strains and deformations in bars, Hooke‗s Law – idealized stress- strain relationships – Poisson's ratio, thermal strain, Saint Venant's principle, Elastic strain energy, Statically indeterminate systems, Strain at a point - Strain Tensor, Constitutive relationships, generalized Hooke's law for isotropic materials, relationships between elastic constants, Thin walled pressure vessels.

Module 2 (13 hours)
Simplification to 2-D problems - plane stress problems - plane strain problems, Axi-symmetric problems – Lame‘s problem - rotating disks and shrink fits. Energy Techniques - introduction to energy methods - strain energy - minimum potential energy principle. Transformation of stresses and strains - equations of transformation - principal stresses, Mohr's circles of stress and strain, Compound stresses - superposition and its limitations - eccentrically loaded members.

Module 3 (12 hours)
Axial force, shear force and bending moment diagrams – sign conventions, Axial force, shear force and bending moments by direct approach, integration, Bending stresses in beams, Elastic flexure formula- bending stresses, Elastic strain energy in bending, Inelastic bending, Bending about both principal axes – Elastic bending with axial loads, Shear stresses in beams - shear flow - shearing stress formulae.

Module 4 (15 hours)
Deflection of beams - direct integration method, singularity functions, superposition techniques, moment area method, elementary treatment of statically indeterminate beams, Torsion - torsion of circular elastic bars, statically indeterminate problems, torsion of inelastic circular bars, strain energy in torsion, Torsion of thin walled tubes, Three dimensional problems- St. Venant‗s theory - Prandtl‗s stress function approach - elliptical and triangular cross sections, Prandtl‗s membrane analogy, Torsion of thin walled open and closed sections.

References

1. Popov, E.P., *Engineering Mechanics of Solids*, 2nd ed., Prentice Hall of India, New Delhi, 2000.
2. Beer, F.P., Johnston, E.R. and De Wolf, J.T., *Mechanics of Materials*, 3rd ed., Tata McGraw-Hill.
3. Timoshenko, S.P. and Young, D.H., *Elements of Strength of Materials*, McGraw-Hill.
4. Irving H. Shames, *Introduction to Solid Mechanics*, 2nd ed., Prentice Hall of India.
5. Crandall, S.H., Dahl, N.C. and Lardner, T.J., *Introduction to Mechanics of Solids*, McGraw-Hill.
6. Ratan, S.S., Strength of Materials, McGraw Hill Education, 3rd Ed, 2017.

Course Code: ME 13103 **L-T-P-C**
Course Title: THERMODYNAMICS **3-1-0-4**
Pre-requisite: NIL

Module 1 (11 hours)
Introduction to thermodynamics – thermodynamic systems – control volume – properties of a system – state and equilibrium – processes and cycles – forms of energy – temperature and zeroth law of thermodynamics, Properties of pure substances – pure substance – phases of a pure substance – phase-change processes of pure substances –property diagrams for phase-change processes – property tables – the ideal-gas equation of state – compressibility factor – other equations of state – internal energy, enthalpy, and specific heats of ideal gases.

Module 2 (12 hours)
Forms of Energy, Energy transfer by heat, work, and mass – concept of heat and work – forms of work – flow work and the energy of a flowing fluid, The first law of thermodynamics – energy balance for closed and open systems – energy balance for steady flow systems – some steady-flow engineering devices – energy balance for unsteady-flow processes.

Module 3 (10 hours)
Limitation of First law- second Law of Thermodynamics- kelvin-Planck statement- Heat Engine, Efficiency, thermal energy reservoirs – heat engines – refrigerators and heat pumps – Clausius statement – equivalence of the two statements, PMM-I, PMM-II, Reversible and irreversible processes, The Carnot cycle, The Carnot principles, The thermodynamic temperature scale, The Carnot heat engine, The Carnot refrigerator and heat pump.

Module 4 (12 hours)
Clausius Inequality, Entropy – increase of entropy principle – entropy change of pure substances – isentropic processes – property diagram involving entropy – the T ds relations – entropy change of liquids and solids – The entropy change of ideal gases, Exergy, Exergy for open and closed systems, Reversible work and irreversibility, Exergy balance equation, Second law efficiency.

Module 5 (6 Hours)
Gas power cycles – Otto, Diesel. Basic Rankine and Refrigeration cycles.

Module 6 (5 Hours)
Thermodynamic property relations – the Maxwell relations – the Clapeyron equation –Clausius-Clapeyron equation, general relations for du, dh, ds, Cv, and Cp, The Joule-Thomson coefficient, The h , u , and s of real gases.

References
1. Sonntag, R.E., and Bornakke, C., *Fundamentals of Thermodynamics*, 7th ed., John Wiley & Sons, 2009.
2. Nag, P.K., *Engineering Thermodynamics*, Tata McGrawHill,
3. Cengel,Y.A., and Boles, M.A., *Thermodynamics: An Engineering Approach*, 4th ed., Tata Mc Graw-Hill, 2003.
4. Moran, M.J., and Shapiro, H.N., *Fundamentals of Engineering Thermodynamics*, 6th ed., John Wiley & Sons, 2008.

Course Code: ME 13104 **L-T-P-C**
Course Title: MATERIALS SCIENCE AND METALLURGY **3-0-0-3**
Pre-requisite: NIL

<u>Course Content</u>

Module 1 (9 hours)
Engineering materials: classification, requirements, properties and selection of engineering materials, Review of fundamentals - Crystal structure, Crystal imperfections, Edge and screw dislocations, interaction between dislocations, Frank-Reed source. Experimental techniques for metallographic studies, optical microscopy, electron microscopy (SEM and TEM), X-ray diffraction, grain size, grain size measurement, ASTM grain size number.

Module 2 (10 hours)
Solidification of metals - cooling curves, nucleation - homogeneous and heterogeneous nucleation, supercooling, critical radius, grain growth, dendritic pattern, equiaxed and columnar grains, grain boundary-grain boundary effects, solidification and structure of castings - coring, homogenization. Alloys - solid solutions - interstitial, substitutional ordered and disordered solid solutions, Hume-Rothery rules, intermetallic compounds, phase diagrams - construction from cooling curves, lever rule, equilibrium diagrams of binary alloys, isomorphous (Cu-Ni), Eutectic (Bi-Cd, Pb-Sn) detailed study of Fe-C systems. Diffusion: mechanisms of diffusion - Fick's laws of diffusion - applications.

Module 3 (11 hours)
Deformation of metals - cold working, hot working, annealing of a cold worked article - recovery, recrystallisation and grain growth, elastic and plastic deformations - mechanisms of plastic deformation, deformation by slip - slip systems - slip planes and slip directions, critical resolved shear stress, deformation by twinning. Strengthening mechanisms - work hardening, solid solution hardening, dispersion hardening, precipitation hardening, grain boundary strengthening. Heat treatment of steels - stress relieving, annealing, normalising, hardening, TTT diagram, tempering, hardenability, Jominy test. Surface hardening - flame hardening, induction hardening, Case hardening - carburising, nitriding, cyaniding, etc. Metallic Coatings, hard facing, metal cladding, anodising, diffusion coatings.

Module 4 (12 hours)
Ferrous alloys: steels - alloy steels, tool steels, stainless steels, effect of alloying elements on properties of steels, cast irons - classification, structure, properties, applications. Non - ferrous alloys - Al and Al alloys, Cu and Cu alloys, Mg and Mg alloys, Zn and Zn alloys - major types, composition, properties and applications. Non-metallic materials - thermoplastics, thermosetting plastics, elastomers, composites, ceramics, glasses. Selection and use of engineering materials, Recent developments in materials science - smart materials, shape memory alloys, functionally graded materials, piezo-electric materials.

References
1. Smith, O.C., *Science of Engineering Materials,* 3rd ed., Prentice Hall, 1985.
2. Callister, W.D., *Materials Science and Engineering: An Introduction,* 7th ed., John Wiley & Sons, 2007.
3. Avner, S.H., *Introduction to Physical Metallurgy,* 2nd ed., McGraw-Hill Inc., 1976.

4. Van Vlack, L.H., *Elements of Materials Science and Engineering,* 6th ed., Addison Wesley Publishing Company, 1989.
5. Shackelford, J.F., *Introduction to Materials Science for Engineers,* 6th ed., Prentice Hall, 2004.
6. Higgins, R.A., *Engineering Metallurgy Part I, Applied Physical Metallurgy,* 6th ed., Viva Books Private Limited, 1998.
7. Raghavan, V., *Material Science and Engineering,* 5th ed., Prentice-Hall of India, 2004.
8. Reed Hill, R.E., *Physical Metallurgy Principles,* 2nd ed., Affiliated East-West Press, 2008.
9. Jastrzebski, Z.D., *Nature and Properties of Engineering Materials,* 2nd ed., John Wiley & Sons, 1976.
10. Charles, J.A., Crane, F.A.A., and Furness, J.A.G., *Selection and Use of Engineering Materials,* 3rd ed., Butterworth Heinemann, 1997.

Course Code: ME 13105 **L-T-P-C**

Course Title: ELECTRICAL MEASUREMENTS AND MACHINES **3-0-0-3**

Pre-requisite: Nil

<u>Course Content</u>

Module 1 (9 hours)
Electromechanical Energy Conversion principles - Types of machines - Basics of rotating machines - Construction - Rotating magnetic field - Principles of operation - Emf and torque equation - Losses and efficiency.

Module 2 (12 hours)
DC Machines: principle of operation – generators and motors – classification –characteristics - starter - speed control - load test - Swinburne‗s test - applications.
Transformers: Single phase Transformer Construction – principle of operation-equivalent circuit using unity p.f load, lagging loads and leading loads– regulation – efficiency – OC and SC tests – introduction to three phase transformer.

Module 3 (15 hours)
Alternators: Types, principle of operation - Synchronous motors: Principle of operation- starting-applications- Introduction to power Generation, Transmission and distribution system. Induction Motors: Principle of operation – types – tests – Torque slip and performance characteristics – starting – speed control schemes – applications.
Single phase and special machines: FHP induction motors – universal motors - stepper motors – servo motors - tacho generators.

Module 4 (6 hours)
Measurement of high and low resistance using Voltmeter/ Ammeter method- Measurement of power in single phase ac circuits using three voltmeter method, three ammeter method and one wattmeter method - Measurement of power in three phase circuits using two wattmeter method- Measurement of Energy using single-phase energy meter.

References

1. Rajput R K, *Electrical and Electronic Measurement and Instrumentation*, S. Chanda Publication
2. Theraja B L, Theraja A K , *A Text Book Electrical Technology: Volume 2, AC and DC Machines*, S. Chanda Publication

Course Code: ME 13201	**L-T-P-C**
Course Title: MACHINE DRAWING	**0-0-3-2**
Pre-requisite: Engineering Graphics	

Course Content

Introduction: Representation of elements of machine drawing: Engineering Materials, Surface finishes, tolerances, sectional views, Screw threads.

Component Drawings: Bolts and Nuts, Locking devices, Keys and Cotter joints, Knuckle Joint, Riveted joints, Shaft Couplings, Bearings and Pipe joints.

Assembly Drawing Practice: Draw the assembly drawings of Stuffing Box, Pedestal Bearing using the component drawings. Machine drawing practice using AutoCAD.

References

1. Bhatt, N.D., and Panchal, V.M., *Machine Drawing,* 43rd ed., Charotar Publishing House, 2008.
2. Narayana, K.L., Kannaiah, P., and Reddy, K.V., *Machine Drawing,* Wiley Eastern, 2005.
3. John, K.C., and Varghese, P.I., *Machine Drawing,* VIP Publishers, 2009.
4. Gill, P.S., *A Text Book of Machine Drawing,* Kalson Publishers, 2001.
5. Sidheswar, N., Kannaiah, P., and Sastry, V.V.S., *Machine Drawing,* Tata McGraw-Hill, 2007.
6. Ajeet Singh, *Machine Drawing: Includes AutoCAD,* 1st ed., Tata McGraw-Hill, 2010.
7. Prof. Pohit Machine Drawing with Auto Cad, Pearson.

Course Code: ME 13202

Course Title: ELECTRICAL MEASUREMENTS AND MACHINES LABORATORY

L-T-P-C

0-0-3-2

Pre-requisite: Electrical Measurements and Machines

<u>Course Content</u>

1. (a) Determination of V-I characteristics of a linear resistor and an incandescent lamp.
(b) Measurement of high and low resistances using Voltmeter/Ammeter method.
2. Measurement of Power in single phase AC circuit using 3Ammeter, 3 Voltmeter and 1Wattmeter methods and determination of circuit parameters.
3. Measurement of Energy using single-phase energy meter and verification by power /time measurements.
4. Measurement of power in 3 phase circuits using two-wattmeter method.
5. Determination of the efficiency and regulation of single-phase transformer by direct loading.
6. Open circuit and short circuit tests on a single-phase transformer and determination of efficiency and voltage regulation at various loading conditions.
7. (a) Study of different types of Starters for 3 phase Induction motors.
(b) Load test on squirrel cage induction motor and determination of its performance characteristics.
8. Load test on slip ring induction motor and determination of its performance characteristics.
9. Determination of Open circuit characteristic and load characteristics of a DC shunt generator.
10. Determination of performance characteristics of a DC shunt motor by conducting load test.
11. Determination of performance characteristics of a DC series motor by conducting load test.
12. Determination of open circuit characteristic of a 3-phase alternator.

References

1. Clayton & Hancock, Performance & Design Of DC Machines, CBS, 3rd ed., 2001.
2. Langsdorf, A.S., Principles of DC Machines, McGraw-Hill, 6th ed., 1959.
3. Say, M. G, Performance & Design of AC Machines, Pitman, ELBS.3rd ed., 1983.
4. Langsdorf, A.S., Theory of AC Machinery, McGraw-Hill., 2nd ed., 2002.
5. Sawhney, A.K, Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai & Sons, 1996.
6. Soni, Gulpta & Bhatnagar, A course in Electric Power, Dhanpat Rai & Sons.

Semester IV							
Sl No	**Code**	**Subject**	**L**	**T**	**P**	**Credit**	**Category**
1	MA 14101	Mathematics IV	3	1	0	4	BS
2	ME 14101	Applied Fluid Mechanics	3	0	0	3	DCS
3	ME 14102	Mechanics of Machinery	3	0	0	3	DCS
4	ME 14103	Basic Manufacturing Processes	3	0	0	3	DCS
5	ME 14104	Principles of Heat Transfer	3	1	0	4	DCS
6	ME 14201	Fluid Mechanics & Fluid Machinery Laboratory	0	0	3	2	DCS
7	ME 14202	Strength of Materials Laboratory	0	0	3	2	DCS
8	ME 14203	Production Engineering Laboratory – I	0	0	3	2	DCS
Total			15	2	9	23	

Semester IV

Course Code: ME 14101 **L-T-P-C**
Course Title: APPLIED FLUID MECHANICS **3-0-0-3**
Pre-requisite: Mechanics of Fluids

Course Content

Module 1 (11 hours)
Introduction to Fluid Machinery, Classification of Fluid Machinery, Dimensional analysis – Rayleigh_s method and Buckingham_s pi method, Principles of models and similitude as applied to turbo-machines – Non-dimensional parameters applicable to hydraulic machines like capacity coefficient, head coefficient, power coefficient and specific speed and as applicable to hydraulics like Reynolds number, Mach number, Froude_s number, Weber_s number and Euler_s number.

Module 2 (6 hours)
Euler_s equation for turbo-machines, Classification of hydraulic turbines – Constructional features of Pelton, Francis and Kaplan turbines, Speed regulation and Performance analysis of hydraulic turbines, Important non-dimensional numbers and characteristics curves, Theory of draft tubes and cavitations in turbines.

Module 3 (10 hours)
Classification of pumps – Features of rotodynamic and positive displacement pumps, Rotodynamic pumps – principle of working - Vortex motion – Spiral motion – Constructional features of centrifugal pumps – Performance analysis - Efficiencies – Classification of centrifugal pumps – Pump characteristics – Theoretical and actual Head- Capacity relationship – Pump selection, Important non-dimensional numbers and characteristics curves, parallel and series operation of pumps, pump laws, Cavitations in pumps, pump and system characteristics, operating points

Module 4 (9 hours)
Positive displacement pumps - Reciprocating pump – principle of working – Effect of acceleration and friction – Use of air vessels, Cavitation, Pump characteristics. Rotary pumps – Working principle of rotary piston pump, vane pump and gear pump, Miscellaneous fluid devices –Fluid coupling and torque converter

Module 5 (6 Hours)
Introduction to flow measurement, working principle and some design features of venturimeter, orifice meter, pitot tube, flow nozzle, rotameter, vent type anemometer, wiers and nothches.

References:
1. Shepherd D.G., *Principles of Turbo machinery,* Macmillan Company, New York, 1956.
2. Jagdish Lal, *Hydraulic Machines*, 6th ed., Metropolitan book Co. private Ltd. New Delhi.
3. Stepanof, A.J.*, Centrifugal and Axial Flow Pumps*, 2nd edition, John Wiley & Sons Inc., New York, 1957.

4. Dixon, S.L, Hall, C.A., *Fluid Mechanics and Thermodynamics of Turbo machinery*, Pergamon Press, 4th ed., 1998.
5. John. M. Vance, *Rotodynamics of Turbomachinery*, Wiley-Interscience Publication, John Wiley & Sons, 1988.
6. Cengel, Y.A, Cimbala, J.M., *Fluid Mechanics: Fundamentals & Applications*, 2nd ed., McGraw-Hill, 2006.

Course Code: ME 14102	**L-T-P-C**
Course Title: MECHANICS OF MACHINERY	**3-0-0-3**

Pre-requisite: Engineering Mechanics

<u>Course Content</u>

Module 1 (12 hours)
Introduction to mechanisms, Applications of mechanisms, Kinematics of mechanisms – kinematic diagrams, Degree of freedom, Position and displacement analysis – graphical methods, Velocity analysis – relative motion – graphical method – instant center, Mechanical advantage, Acceleration analysis – graphical method.

Module 2 (10 hours)
Analytical methods in mechanism analysis, Computer oriented methods in kinematic analysis, Cam Design, Cam and follower types, Displacement diagrams, Cam profile synthesis – graphical and analytical methods, Design of plate cam – reciprocating flat faced follower – roller follower, Advanced cam profile techniques.

Module 3 (10 hours)
Gears – Law of gearing, Involute spur gears – involutometry, Spur gear details – interference – backlash, Gear standardization, Internal gear, Cycloidal gear, Non-standard gears, Bevel, helical and worm gearing, Gear Trains – simple and compound gear trains – planetary gear trains – solution of planetary gear train problems – applications.

Module 4 (10 hours)
Kinematic synthesis, Tasks of kinematic synthesis – type and dimensional synthesis – graphical synthesis for motion – path generation without and with prescribed timing, Function generation – overlay method, Analytical synthesis techniques, Complex number modelling – loop closure equation technique – Freudenstein's equation, Case studies in synthesis of mechanisms.

References
1. Uicker, J.J.Jr., Pennock, G.R., and Shigley, J.E., *Theory of Machines and Mechanisms*, 3rd ed., Oxford University Press, 2009.
2. Sandor, G.N., and Erdman, A.G., *Advanced Mechanism Design: Analysis and Synthesis, Vol. I & II*, Prentice-Hall of India, 1988.
3. Mabie, H.H., and Reinholtz, C.F., *Mechanisms and Dynamics of Machinery*, 4th ed., John Wiley & Sons, 1987.
4. Ghosh, A, and Mallik, A.K., *Theory of Mechanisms and Machines*, 3rd ed., Affiliated East-West Press, 1998.
5. Waldron, K.J., and Kinzel, G.L., *Kinematics, Dynamics and Design of Machinery*, John Wiley & Sons, 2004.
6. Norton, R.L., *Design of Machinery*, Tata McGraw-Hill, 2004.
7. Martin, G.T., *Kinematics and Dynamics of Machines*, McGraw-Hill, 1969.

8. Rattan, S.S., *Theory of Machines*, 3rd ed., Tata McGraw-Hill, 2009.
9. Nikravesh, P.E., *Planar Multibody Dynamics*, CRC Press, 2008.

Course Code: ME 14103 **L-T-P-C**
Course Title: BASIC MANUFACTURING PROCESSES **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (11 hours)
Types of Production and Production Process, Product features and Manufacturing Methods. Foundry: foundry materials - moulding and core sand - binders - additives, sand preparation - sand control tests, pattern and pattern making, mould and core making, expendable and non-expendable moulds, mould assembly, melting furnaces and melting practice, pouring and fettling, solidification of pure metals and alloys, grain growth.

Module 2 (10 hours)
Casting processes - sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, centrifugal casting, casting design, gateway system design, riser design casting alloys, casting defects and remedial measures, inspection, testing - destructive and non - destructive, casting alloys, economics of casting.

Module 3 (7 hours)
Metal forming operations, hot and cold working of metals, principle, defects in metal forming processes. Process and equipment for drawing, extrusion, rolling, forging and sheet metal working. Analysis of forming operations - load calculation for drawing, extrusion, rolling, forging.

Module 4 (9 hours)
Metal joining - classification, welding heat sources, arc welding machines, arc production, arc characteristics, metal transfer, welding electrode, arc welding, resistance welding, TIG, MIG, submerged arc welding, friction welding, forged welding, gas welding. Defects of welding and their remedies. Welding joints, pre and post processing, residual stresses and distortion, testing of welded joints, brazing and soldering.

Module 5 (5 hours)
Basic Machining Process: Turning, Taper Turning, Grooving, Forming, Threading, Drilling, boring etc. Basic milling and shaping operations, introduction to other basic machining operations: grinding, drilling, planning etc.

References

1. Ghosh, A., and Mallik, A.K., *Manufacturing Science,* Affiliated East west Press Ltd, 2001.
2. Heine, R., Loper, C., and Rosenthal, P., Principles of Metal Casting, Tata McGraw Hill, 2004.
3. Rao, P.N., *Manufacturing Technology (Foundry, Forming and Welding)*, Tata McGraw Hill, 1987.
4. Little, R., *Welding and welding Technology,* Tata McGraw Hill, 2004.
5. Kalpakjian, S., *Manufacturing Engineering & Technology,* Addison Wesley Longman Limited, 1995.

6. Flemings, M.C., *Solidification Processes,* McGraw Hill, American Welding Society, Welding Hand Book.
7. Doyle, L.E., *Manufacturing Processes and Materials for Engineers, 3rd ed.,* Prentice Hall of India, 1984.
8. Taylor, H.F., Flemings, M.C., and Wulff, J., *Foundry Engineering,* 1st ed., John Wiley & Sons Inc, 1959.
9. *Metals Hand Book – Vol. 5,* Welding Institute of Metals, USA.
10. Degarmo, E.P., Black, J.I., and Khosar, R.A., *Materials and Processes in Manufacturing*, Prentice Hall of India.

Course Code: ME 14104 **L-T-P-C**
Course Title: PRINCIPLES OF HEAT TRANSFER **3-1-0-4**
Pre-requisite: Thermodynamics

Course Content

Module 1 (13 hours)
Heat transfer - modes of heat transfer , conduction heat transfer , Fourier‘s law, general heat conduction equations in Cartesian, cylindrical and spherical coordinates - initial and boundary conditions - one-dimensional steady state conduction with and without heat generation , temperature dependence of thermal conductivity , introduction to two dimensional steady state conduction, unsteady state heat conduction in one dimension - lumped heat capacity system , semi-infinite solids with sudden and periodic change in surface temperature, Heisler chart.

Module 2 (17 hours)
Convective heat transfer - Newton's law of cooling , Prandtl number, hydrodynamic and thermal boundary layer equations, laminar forced convection heat transfer from flat plates - similarity and integral solutions , internal flow and heat transfer - fully developed laminar flow in pipes , turbulent forced convection - Reynolds analogy , empirical relations in forced convection , natural convection - integral formulation of natural convection heat transfer from vertical plates , empirical relations in free convection., Condensation and boiling - film and drop wise condensation –pool boiling curves, empirical relations for heat transfer with phase change

Module 3 (13 hours)
Radiation heat transfer – electromagnetic radiation spectrum, thermal radiation, black body, gray body, monochromatic and total emissive power, Planck_s law, Stefan-Boltzmann law , Wein's Displacement law , absorptivity , reflectivity , transmissivity , emissivity , Kichhoff's identity , radiation exchange between surfaces - shape factors for simple configurations , heat transfer in the presence of re-radiating surfaces , radiation shields, surface and shape resistances , electrical network analogy.

Module 4 (13 hours)
Applications of heat transfer like extended surfaces, critical insulation thickness, heat exchangers, heat pipes etc. Analysis of fins with constant area of cross section, Heat Exchangers - LMTD, correction factors, heat exchanger effectiveness and number of transfer units.-Design of heat exchangers –Compact heat exchangers , introduction to Heat pipes and their applications, Multiple-mode heat transfer problems.

References

1. Holman, J.P., *Heat Transfer*, 9th ed., Tata McGraw Hill, 2005.
2. Incorpera, F.P. and De Witt, D.P., *Fundamentals of Heat and Mass Transfer*, John Wiley.
3. Kreith, F., *Heat Transfer*, International Text Book Company. 4 Gebhart, B., *Heat Transfer*, McGraw Hill.
4. Gebhart, B., *Heat Transfer*, McGraw Hill.

Course Code: ME 14201 **L-T-P-C**
Course Title: FLUID MECHANICS AND FLUID MACHINERY LAB **0-0-3-2**
Pre-requisite: Mechanics of Fluids/Applied Fluid Mechanics

<u>Course Content</u>

Study of plumbing tools and pipe fittings, Study of measuring instruments, Measurement of metacentric height and radius of gyration of a floating body, Calibration of flow measuring devices - venturimeter- orifice meter – notches and weirs - nozzle meters, Determination of loss of head due to friction in pipes, Verification of Bernoulli_s theorem, Determination of lift and drag coefficients of cylinder and airfoil, Demonstration of laminar and turbulent flow in pipes - critical velocity, Forces on curved and plane surfaces, Experiments on turbines - performance and operating characteristics, Experiments on pumps - centrifugal pumps - reciprocating pumps - gear pumps, Experiment on torque converter.

Course Code: ME 14202 **L-T-P-C**
Course Title: STRENGTH OF MATERIALS LAB **0-0-3-2**
Pre-requisite: Elements of Solid Mechanics

<u>Course Content</u>

Tension test on MS rod, Shear Test on MS rod, Torsion test on MS Specimen, Hardness tests on metals, Impact tests on metals, Bending test on steel beams, Spring test – open and close coil springs, Compression test on cubes and cylinders – determination of modulus of elasticity, Study of extensometers and strain gauges.

Course Code: ME 14203 **L-T-P-C**
Course Title: PRODUCTION ENGINEERING LABORATORY – I **0-0-3-2**
Pre-requisite:

<u>Course Content</u>

Introduction to moulding practice – preparation of moulding sand and use of moulder‘s tools; making of moulds by using selected pattern‘s; introduction to melting and pouring practice; experiments sand testing like permeability, moisture content, shutter index, mould strength, grain fineness number etc.
Welding: Study of SAW, MIG, TIG, Resistance spot welding.
Forming operations: rolling, drawing, extrusion
Classifications of machine tools and machining processes - Specification of machine tool, power source, Machining on Centre lathe – Various Lathe operations, Methods of holding work – Tolerance and surface finish, Cutting tools - Materials, types. Study and grinding of various cutting tools.

Semester V							
Sl No	**Code**	**Subject**	**L**	**T**	**P**	**Credit**	**Category**
1	ME 15101	Machine Design I	3	1	0	4	DCS
2	ME 15102	Thermal Engineering I	3	0	0	3	DCS
3	ME 15103	Theory of Metal Cutting	3	0	0	3	DCS
5	ME 15104	Machine Tool Design	3	0	0	3	DCS
6	ME 15105	Dynamics of Machinery	3	0	0	3	DCS
7	ME 15201	Heat Transfer Laboratory	0	0	3	2	DCS
8	ME 15202	Production Engineering Laboratory II	0	0	3	2	DCS
Total			15	1	6	20	

Semester V

Course Code: ME 15101 **L-T-P-C**
Course Title: MACHINE DESIGN – I **3-1-0-4**
Pre-requisite: Elements of Solid Mechanics

Course Content

Module 1 (17 hours)
Introduction to Design – steps in design process – design factors, Principles of standardization, Selection of materials, Statistical considerations in design, Stress concentration, Theories of failure, Impact load, Fatigue loading, Consideration of creep and thermal stresses in design.

Module 2 (13 hours)
Threaded fasteners – thread standards – stresses in screw threads – analysis of power screws – bolted joints – preloading of bolts – gasketed joints – eccentric loading, Riveted joints – stresses in riveted joints – strength analysis – boiler and tank joints – structural joints, Keys and pins – types of keys and pins – stresses in keys and pins – design of cotter and pin joints.

Module 3 (13 hours)
Welded joints – types of welded joints – stresses in butt and fillet welds – torsion and bending in welded joints – welds subjected to fluctuating loads – design of welded machine parts and structural joints, Springs – stresses in helical springs – deflection of helical springs – extension, compression and torsion springs – design of helical springs for static and fatigue loading – critical frequency of helical springs – stress analysis and design of leaf springs.

Module 4 (13 hours)
Power shafting – stresses in shafts – design for static loads – reversed bending and steady torsion – design for strength and deflection – design for fatigue loading – critical speed of shafts, Stresses in couplings, Design of couplings, Design of keyed and splined connections.

<u>Text/Reference Books</u>

1. Shigley, J.E., Mechanical Engineering Design, 1st Metric ed., McGraw-Hill, 1986.
2. Shigley, J.E. and Mischke C.R., Mechanical Engineering Design, 6th ed., Tata McGraw-Hill, 2003.
3. Siegel, M.J., Maleev, V.L. and Hartman, J.B., Mechanical Design of Machines, 4th ed., International Textbook Company, 1965.
4. Phelan, R.M., Fundamentals of Mechanical Design, Tata McGraw-Hill, 1967.
5. Doughtie, V.L. and Vallance, A.V., Design of Machine elements, McGraw-Hill, 1964.
6. Juvinall, R.C. and Marshek, K.M., Fundamentals of Machine Component design, 3rd ed., John Wiley & Sons, 2000.
7. Norton, R.L., Machine Design, 2nd ed., Pearson Education, 2000.

8. Bhandari, V. B., *Design of Machine Elements,* McGraw Hill Education India Pvt. Ltd. 4th Ed, 2017

Course Code: ME 15102 **L-T-P-C**
Course Title: THERMAL ENGINEERING-I **3-0-0-3**
Pre-requisite: Thermodynamics/Principle of Heat Transfer

<u>Course Content</u>

Module 1 (10 Hours)
Power cycles– Gas and vapour power cycles- Carnot cycle and its limitations-air standard cycles- Otto - Diesel & Dual combustion cycles, Brayton cycle, Comparison among these cycles, Miller, Stirling and Ericson cycles, Real air-fuel cycles, SI engine cycle at part throttle and supercharged conditions, Four stroke and Two stroke engines, Valve timing & Port timing diagrams, Scheme of scavenging - Scavenging efficiency.

Module 2(4 Hours)
Fuels, stoichiometric Air, Equivalence ratio, first law of thermodynamics applied to combustion process

Module 3 (9 Hours)
Classification of IC engines – SI engine, CI engine, 2 stroke and 4 stroke engine, Terminology, variables and abbreviations. 2 stroke and 4 stroke SI engine, process of fuel injection. Ignition, Self -Ignition temperature, Ignition lag (delay), Normal combustion in SI engines, Engine knock – effect of variables on tendency to knock – Octane Number – Pre-ignition, Engine systems – Intake and Exhaust, Transmission, Cooling, Lubrication, Starting systems

Module 4 (9 Hours)
2 stroke and 4 stroke CI engine, Normal combustion in CI engines, Diesel knock – Cetane Number, Alternate fuels for diesel engines - Multiple Port Fuel Injection (MPFI), Throttle body fuel Injection - IC Engine performance – constant speed and variable speed characteristics - Different methods to determine Friction Power – Variation of volumetric efficiency with speed and load, Heat Balance, Engine Emission and Air pollution – Catalytic converters and EGR.

Module 5 (10 Hours)
Analysis of Gas Turbine cycles - Regeneration - Reheat and Inter cooled cycles – Ideal Jet – propulsion cycles, Modifications to turbojet engines, Actual Brayton cycle, Open and Closed cycles, Combustion chambers for gas turbines, A/F ratio and stability loop,

<u>Text/Reference Books</u>

1. Yunus A. Cengel and Michael A. Boles, Thermodynamics – An engineering approach, 3rd ed., Mc Graw-hill Professional, 1998
2. Willard W and Pulkrabek, Engineering Fundamentals of Internal combustion Engines,2nd ed., Phi Learning., New Delhi, 2009

3. Henry Cohen, Rogers G. F. C and Saravanamuttoo H. I. H, Gas Turbines Theory, 4th ed., Heritage Publishers, 1996
4. John B. Heywood, Internal Combustion Engine Fundamentals, 1st ed., McGraw-Hill, 1998.
5. Mathur L. and. Sharma R. P, A Course in Internal combustion Engines, 7th ed.,Dhanpat Rai Publications (P) Ltd., 1999.
6. Ganehan V, *Internal Combustion Engines*, MaGraw Hill Education, 2012

Course Code: ME 15103	**L-T-P-C**
Course Title: THEORY OF METAL CUTTING	**3-0-0-3**
Pre-requisite: Basic Manufacturing Processes	

Course Content

Module 1 (14 hours)
Tool Geometry: Geometrical parameters of turning tool in ASA, ORS, NRS and MRS systems. Inter-relation of different systems of rake and clearance angle nomenclature; projection method, vector method, and master line method. Geometry of twist drills, plane milling cutters and face milling cutters. Geometries of standard turning and face milling inserts. Sharpening of turning tools, twist drills and face milling cutters.

Module 2 (12 hours)
Chip Formation Mechanism: Formation of built up edge and its effect on machining, classification of chips, chip reduction coefficient and its significance.
Cutting tool temperature: Temperature distribution in cutting tools; effect of cutting speeds, measurement of tool temperature.
Cutting Fluids: Types of cutting fluids, method of cutting fluid application, mechanism of cutting fluid action, cryogenic cooling.
Failure of Cutting Tools: Tool wear and fracture, types of tool wear. On-line and Off-line tool condition monitoring. Taylor‘s tool life equation, machining of FRP composites.

Module 3 (9 hours)
Cutting forces in turning, drilling and milling: Merchant‘s circle diagram; Kronenberg‘s relationship. Effect of restricted contact and nose radius. Dynamic shear stress and its significance. Principles of dynamometry. Types of dynamometers. Basic principles of strain gauge type turning, milling and grinding dynamometer design. Limitation of strain gauge type dynamometers, Piezoelectric dynamometers.

Module 4 (9 hours)
Machining by Abrasive: Mechanisms of grinding, wheel wear, wheel loading and auto-sharpening, wheel dressing and truing. Effects of dressing parameters in grinding. Mechanisms of material removal in lapping, honing and superfinishing. CBN and Diamond grinding.
Tool Materials: History of development. HSS, carbides, ceramic, CBN and Diamond as tool materials, Effects of coating on tool performance.

References

1. Stephenson, D.A., and Agapiou, J.S., *Metal Cutting Theory and Practice*, 3rd ed., Taylor & Francis, CRC Press, 2016

2. Bhattacharyya, A., *Metal cutting: theory and practice*, Central Book Publishers, 1996

3. Juneja B.L., Sekhon, G.S., and Seth, N., *Fundamentals of Metal Cutting and Machine Tools*, New Age International.

4. G. Boothroyd, Fundamentals of Metal Machining and Machine Tools, McGraw Hill, TSE

5. Chattopadhyay, A.B., *Machining and Machine tools*, John Wiley & Sons, 2011.

6. Rao, P.N., *Manufacturing Technology: Metal cutting and machine tools vol- 2*, McGraw Hill India, 2013.

Course Code: ME 15104 **L-T-P-C**
Course Title: MACHINE TOOL DESIGN **3-0-0-3**
Pre-requisite: Basic Manufacturing Processes

Course Content

Module 1 (10 hours)
Determination of Machine Tools, Development, Classification and the spectrum of Operation Performed in Machine Tools. Tool in hand nomenclature, basic parameters of metal cutting i.e. speed, feed and depth of cut in relation to turning, milling, shaping and drilling operations. Calculations of cutting speeds and machining times for turning, shaping, drilling and milling, HSS and carbides as tool materials.

Module 2 (11 hours)
External features of a centre lathe, Schematic representation of lathe operations, classification of lathes, lathe accessories. Classification of drilling machines, external features of pillar and radial drilling machines, Drill specification without details of drill geometry Schematic representation of drilling, boring and reaming operations.

Module 3 (10 hours)
External features of a shaping machine. Classification of milling machines and cutters, milling operations, Arbours, dividing head and its uses. Selection of speed range, Upper and lower speed limits of a lathe, layouts for intermediate spindle speeds in A.P, G.P. and L.P. Saw diagrams, productivity loss, selection of values of common ratio in a G.P. layout. General features of all-geared head stock. Design of all general head stock. Application of clutches as a gear box elements.

Module 4 (11 hours)
Feed mechanisms in lathe, drilling and milling machines, Examples of mechanical stepless drives, Hydraulic drives, its advantages, example of a simple hydraulic drive scheme. Shapes of machine tools slideway, bed and slideway materials, qualitative description of bass and roller guides and recirculation ball screws, qualitative studies of stick slip motion and its remedy. Qualitative description of machine tool vibration, its effects and sources, vibration elimination, Definition of chatter.

References

1. Sen, G.C., and Bhattacharyya, A., *Principles of Machine tools*, New Central Book Agency.

2. Chattopadhyay, A.B., *Machining and Machine tools*, John Wiley & Sons, 2011

3. Boothroyd, G., *Fundamentals of Metal Machining and Machine Tools*, McGraw Hill, TSE

4. Chernov, N., *Machine Tools*, Mir Publisher

5. Acherkan, N., *Machine Tool Design,* Vol – 1, 2 & 3, Mir Publishers, Moscow

Course Code: ME 15105 **L-T-P-C**
Course Title: DYNAMICS OF MACHINERY **3-0-0-3**
Pre-requisite: Mechanics of Machinery

Course Content

Module 1 (14 Hours)
Constraint and applied forces, Static equilibrium, Equilibrium of two and three force members, Member with two forces and a torque, Equilibrium of four force members, Force conventions, Free body diagrams, Superposition, Principle of virtual work, Friction in mechanisms. Force analysis of spur, helical and bevel gears. D'alemberts principle, Equivalent offset inertia force, Dynamic analysis of four link mechanisms, Dynamic analysis of slider crank mechanisms, Velocity and acceleration of a piston, Angular velocity and angular acceleration ofconnecting rod, Engine force analysis, Turning moment on a crank shaft, Dynamically equivalent system, Inertia of the connecting rod, Turning moment diagram, Fluctuation of energy, Flywheels, Dimensions of flywheel rims, Punching press.

Module 2 (8 Hours)
Static Balancing, Dynamic Balancing, Transference of a force from one plane to another, Balancing of several masses in different planes, Balancing of Reciprocating mass, Balancing of Locomotives, Effects of partial Balancing in locomotives, Secondary Balancing, Balancing of inline engines, Balancing of V- engines, Balancing of Radial engines.

Module 2 (12 Hours)
Angular Velocity, Angular Acceleration, Gyroscopic Torque (Couple), Gyroscopic effect on Aeroplanes, Gyroscopic effect on Naval ships, Stability of an Automobile, Stability of a Two- wheel vehicle. Types of Governors, Watt Governor, Porter Governor, Proell Governor, Hartnell Governor, Inertia Governor, Sensitiveness of a Governor, Hunting, Isochronism, Stability, Effort of a Governor, Power of a Governor, Controlling force.

Module 2 (8 Hours)
Mechanical vibrations: Basic concepts of degree of freedom, free undamped and damped vibrations of single degree of freedom systems, force vibration with viscous damping, rotating and reciprocating unbalance, vibration isolation and transmissibility, whirling of shaft, free torsional vibrations of single rotor, two rotor and three rotor systems, Torsionally equivalent shaft.

Text/Reference Books

1. Uicker, J.J. Jr., Pennock, G.R., and Shigley, J.E., Theory of Machines and Mechanisms, 3d ed., Oxford University Press, 2009.

2. Mabie, H.H., and Reinholtz, C.F., Mechanisms and Dynamics of Machinery, 4d ed., JohnWiley & sons, 1987.
3. Ghosh, A, and Mallik, A.K., Theory of Mechanisms and Machines, 3d ed., Affiliated East-West Press, 1998.
4. Holowenko, A.R., Dynamics of Machinery, John Wiley & Sons, 1965.
5. Waldron, K. J., and Kinzel, G. L., Kinematics, Dynamics and Design of Machinery, John Wiley & Sons, Inc., 2004.
6. Norton, R.L., Design of Machinery, Tata McGraw-Hill, 2004.
7. Rattan, S.S., Theory of Machines, 3d ed., Tata McGraw-Hill, 2009.
8. Nikravesh, P.E., Planar Multibody Dynamics, CRC Press, 2008.

Course Code: ME 15201 **L-T-P-C**
Course Title: HEAT TRANSFER LABORATORY **0-0-3-2**
Pre-requisite: Principle of Heat Transfer

Course Content

Thermal conductivity of a metal rod, Unsteady state conduction heat transfer, Forced convection heat transfer, Emissivity measurement, Natural Convection heat transfer, Drop wise and film wise condensation, Boiling Heat transfer, Fins, Vapour Compression Refrigeration System, Heat exchangers, Interferometric measurement of temperature field.

Course Code: ME 15202 **L-T-P-C**
Course Title: PRODUCTION ENGINEERING LABORATORY II **0-0-3-2**
Pre-requisite:

Course Content

Centre lathe, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines: general features, parts and functions, machine shop work involving different operations by using the drilling machines, shaping machines, planning machines, slotting machines, milling machines and grinding machines through making of jobs. Cutting variables - Selection of speeds, feeds and depth of cut - Use of cutting fluids
Experiments on: Study of the speed structure of a lathe, study of apron mechanism and calibration of feeds in a lathe.

Semester VI							
Sl No	**Code**	**Subject**	**L**	**T**	**P**	**Credit**	**Category**
1	ME 16101	Thermal Engineering II	3	0	0	3	DCS
2	ME 16102	Metrology and Instrumentation	3	0	0	3	DCS
3	ME 16103	Machine Design II	3	1	0	4	DCS
5	ME 163xx	Elective I	3	0	0	3	DE
6	HS 16101	Professional Communication	2	0	0	2	HL
7	ME 16401	Seminar	0	0	3	2	DCS
8	ME 16201	Dynamics of Machine Laboratory	0	0	3	2	DCS
9	ME 16202	Production Engineering Laboratory III	0	0	3	2	DCS
Total			14	1	8	20	

Semester VI

Course Code: ME 16101 **L-T-P-C**
Course Title: THERMAL ENGINEERING – II **3-0-0-3**
Pre-requisite: Thermodynamics/ Thermal Engineering I

Course Content

Module 1 (8 hours)
Vapour and combined power cycle – Carnot vapour cycle – Ideal Rankine cycle – deviations in an actual Rankine cycle – methods to increase the efficiency of the Rankine cycle – Reheat and Regenerative cycles, Open and closed feed water heaters – deaerator – co-generation –super critical cycle, combined cycles.

Module 2 (10 hours)
Steam generators – classification, general features of utility boilers, circulation, Mountings and accessories – combustion equipment – pulverized coal burners – cyclone furnace – fluidized-bed combustion, Fans and drafts, Economizer, air pre heater, super heater, re-heater, Steam nozzles – condition for maximum discharge – design for throat and exit areas – effect of friction – supersaturated flow,

Module 3 (10 Hours)

Steam turbines – classification – impulse and reaction turbine – velocity diagrams – efficiencies – end thrust – blade height –Compounding of stream turbine, turbine performance and governing

Module 4 (4 hours)
Condensers – air extraction, cooling tower, purpose of a condenser in a steam power plant – surface and mixing condensers, Different types of modern wet and dry cooling towers.

Module 5 (10 hours)
Power Plant Economics – load curve and load duration curve – load, Diversity, Capacity and use factors – selection of size and number of units – scheduling of operation – depreciation and replacement – environmental aspects of thermal power systems, Dust collectors, Pollution by power plants, gasses and particulate pollutants, Effects on life and property, methods of control.

References

1. Y.A, Cengel, and M.A, Boles, Thermodynamics - An engineering approach, 4th ed., Tata McGraw Hill, New Delhi, 2005.
2. M.M, El-Wakil, Power Plant Engineering, 1st ed., McGraw Hill, New York, 1985.

3. W.A., Vopat, and B.G.A., Skrotzki, Power Station Engineering and Econom. Tata McGraw Hill, New Delhi, 1999.
4. Husain, and Zoeb, Steam turbines, Tata McGraw Hill, 1984.
5. Nag. P.K., Power Plant Engineering, McGraw Hill Education 2008.

Course Code: ME 16102 **L-T-P-C**
Course Title: METROLOGY AND INSTRUMENTATION **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (12 hours)
Statistical concepts - Sampling, least squares model, covariance and correlation. Calculation of uncertainties - Law of propagation, correlated inputs, probability densities, sampling distributions, case studies and problems. Experiment planning: Factors, Interference, Randomization, Repetition and Replication, Concomitant methods. Dynamic characteristics: General model, Zero order, First order - Step response and Frequency response, Second order- Step response and frequency response, Experimental determination of parameters.

Module 2 (10 hours)
Metrology: Dimensional and angular measurement - Slip gauges, Comparators, Abbe‗s principle. Pneumatic transducer, Electronic transducers, Sine bar, angle gauges. Thread measurement, Gear measurement, Flatness Measurement, Interferometer, Co-ordinate Measuring Machine (C.M.M) Surface finish - Parameters, Stylus instruments. Pressure measurements- Manometers,

Module 3 (10 hours)
Strain measurement- Resistance & semiconductor strain gauges, circuits and arrangements. Elastic transducers. Force & Torque measurements. Temperature measurement - Expansion thermometers, Resistance Temperature Detectors, Thermistors, Thermocouples, radiative measurements.

Module 4 (10 hours)
Instrumentation, microcontroller, P.L.C & its applications, concept of feedback: open loop & closed loop control system: Linear system, Transfer function, Block diagram, Servo System.

References

1. Kirkup, L., and Frenkel, R.B., An Introduction to Uncertainty in Measurement Using the GUM, Cambridge University Press, 2006.
2. Doebelin, E.O., Measurement Systems, 5th ed., McGraw-Hill International, 2004.
3. Collett, C.V., and Hope, A.D., Engineering Measurements, 2nd ed., ELBS/Longman, 1983.
4. Beckwith, T.G., Marangoni, R.D., and Lienhard, J.H., Mechanical Measurements, 5th ed., Pearson Education, 1993.
5. Galyer, J.F.W., and Shotbolt, C.R., Metrology for Engineers, 5th ed., Thomson Learning, 1990.
6. Holman, J.P., Experimental Methods for Engineers, 7th ed., McGraw-Hill Company, 2000.
7. Raghavendra N.V., Krishnamurti L., Engineering Metrology and Measurement, Oxford University Press, 2013.

Course Code: ME 16103 **L-T-P-C**
Course Title: MACHINE DESIGN – II **3-1-0-4**
Pre-requisite: Elements of Solid Mechanics/Machine Design I

Course Content

Module 1 (15 hours)
Design of clutches, brakes, belts and chain drives – friction clutches and brakes – uniform pressure and uniform wear assumptions – design of disc and cone types of clutches and brakes – design of external contracting and internal expanding elements – band type clutches and brakes – belt and chain drives of common types – design of flat and V-belt drives – selection of roller chains.

Module 2 (15 hours)
Design of gears – spur, helical, bevel and worm gears – tooth loads – gear materials – design stresses – basic tooth stresses – stress concentration – service factor – velocity factor – bending strength of gear teeth – Buckingham_s equation for dynamic load – surface strength and durability – heat dissipation – design for strength and wear.

Module 3 (15 hours)
Lubrication and journal bearing design – types of lubrication and lubricants – viscosity – journal bearing with perfect lubrication – hydrodynamic theory of lubrication – design considerations – heat balance – journal bearing design, Rolling Contact Bearings – bearing types – bearing life – static and dynamic capacity – selection of bearings with axial and radial loads – lubrication – seals – shaft, housing and mounting details.

Module 4 (11 hours)
Product design for manufacturing – general design recommendations for rolled sections – forgings – screw machine products – turned parts – machined round holes – parts produced on milling machine – welded parts and castings –modification of design for manufacturing easiness for typical products.

References

1. Shigley, J.E., Mechanical Engineering Design, 1st Metric ed., McGraw-Hill, 1986.
2. Shigley, J.E. and Mischke C.R., Mechanical Engineering Design, 6th ed., Tata McGraw-Hill, 2003.

3. Siegel, M.J., Maleev, V.L. and Hartman, J.B., Mechanical Design of Machines, 4th ed., International Textbook Company, 1965.
4. Phelan, R.M., Fundamentals of Mechanical Design, Tata McGraw-Hill, 1967.
5. Doughtie, V.L. and Vallance, A.V., Design of Machine elements, McGraw-Hill, 1964. 6. Juvinall, R.C. and Marshek, K.M., Fundamentals of Machine Component design, 3rd ed., John Wiley & Sons, 2000.
7. Norton, R.L., Machine Design, 2nd ed., Pearson Education, 2000.
8. James G. Bralla, Handbook of Product Design for Manufacture, McGraw Hill Data
9. Bhandari, V. B., *Design of Machine Elements,* McGraw Hill Education India Pvt. Ltd. 4th Ed, 2017

Handbooks (allowed for reference during examinations also)

1. Narayana Iyengar, B.R. and Lingaigh, K., Machine Design Data Handbook, Vol. I & II 2. P.S.G. Tech., Machine Design Data Hand Book.

<u>ELECTIVE I</u>

Course Code: ME 16301 **L-T-P-C**
Course Title: THEORY OF PLASTICITY **3-0-0-3**
Pre-requisite: Elements of Solid Mechanics

<u>Course Content</u>

Module 1 (10 hours)
Introduction to plasticity - theory of plasticity - yield criteria for metals - stress strain relationship. Material properties,– behaviour of metals under uni-axial tension and compression — true stress-true strain relations — Equations of elasticity - equation of equilibrium - strain-displacement equations, compatibility conditions - constitutive equations -Navier equations, Boundary conditions – traction - displacement and mixed boundary conditions. Special problems in bending - unsymmetrical bending - shear centre.

Module 2 (10 hours)
Yield criterion – stress space representation of yield criterion – representation of Tresca and von-Mises criterion – yield surface for work hardening materials, Stress strain relations in the plastic range — Prandtl -Reuss, Levy-Mises and St. Venant_s stress-strain relations, Plastic potential, Principle of maximum work dissipation.

Module 3 (12 hours)
Elastic-Plastic analysis – pure bending of a beam – torsion of circular bar – thick spherical shell under internal pressure – thick cylindrical shell under internal pressure – rotating cylinders – rotating disks, Plane strain problems – simple slip line fields, Bound theorems and their applications Columns - theory of columns - buckling theory - Euler's formula - effect of end conditions - eccentric loads and secant formula.

Module 4 (10 hours)
Effect of work hardening, Bollarding and Barrelling, Empirical stress-strain relations for work hardening materials. Application of the theory of plasticity to metal forming operations – plasticity analysis of extrusion and drawing of wires and strips – analysis of tube drawing with mandrels – analysis of rolling – analysis of forging, Load calculations for the operations.

References

1. Chakrabarty, J., *Theory of Plasticity*, Van-Nostrand Reinhold Co., London, 1975.

2. Johnson, W., and Meller, P.B., *Engineering Plasticity,* Mc-Graw Hill Book Co., New York, 1987.

3. Hoffman, O. and Sachs, G., *Introduction to the theory of Plasticity for Engineers*, Mcgraw Hill Book Co., New York, 1953.

ELECTIVE I

Course Code: ME 16302 **L-T-P-C**
Course Title: COMPUTATIONAL FLUID DYNAMICS **3-0-0-3**
Pre-requisite: Mechanics of Fluids

Course Content

Module 1 (10 hours)
Introduction to analytical, numerical and computational methods, Mathematical description of physical phenomena, Physical significance for mathematical classifications of partial differential equations as elliptic, parabolic and hyperbolic, Physical meaning of general partial differential equations, Simplification methods – proper choice of coordinate – transformed coordinates – normalization, Physical domain and computational domain, Discretization methods for converting derivatives to their finite difference forms – Taylor series method – polynomial fitting method – integral method and physical formulation, Discretization error, first order, second order and higher order accuracy discretization methods.

Module 2 (10 hours)
Model equations – Laplace‗s equation – heat equation – first order wave equation – Burger‗s equation (INVISCID), Computational methods for one, two, three-dimensional steady state conduction problem in Cartesian and cylindrical co-ordinates, Methods to deal Dirichlet, Neumann and Robins type boundary conditions for regular and irregular shapes, Fine, coarse, uniform and non-uniform grids, Solution of the linear algebraic equations – Gaussian elimination method – Tri-diagonal Matrix Algorithm (TDMA), Iterative methods – Gauss-Seidel point by point method – Gauss Seidel line by line methods – under and over relaxations.

Module 3 (10 hours)
Computational Methods for one, two and three-dimensional heat equations - explicit, implicit, Crank-Nicholson, ADI schemes, ADE schemes, Fractional step methods, Hopscotch scheme, Douglass scheme, Conservative form of partial differential and finite difference equations, Methods to deal interface property and non-linearity, Consistency, stability and convergence of

Computational methods, discrete perturbation stability analysis, Von- Neumann stability analysis, Validation of computational solution.

Module 4 (12 hours)
Computational methods of first order wave equations and Burger_s Equation (INVISCID) – explicit schemes – implicit schemes – upstream difference schemes – Lax–Wendroff scheme – Mac Cormack – hybrid and power law schemes, Dissipation and dispersion errors, Four basic rules to obtain consistency and stability, Computation of the flow field using stream function- vorticity formulation, Analysis of two dimensional incompressible viscous flow inside a Lid Driven Cavity, Algorithms to obtain flow field by solving coupled system of equations – semi implicit methods for pressure linked equations and its revised schemes.

References
1. Anderson, D.A., Tennehill J.C., and Pletecher R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere, 1984.
2. Patankar, S.V. Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980.
3. Muraleedhar, K., and Sundararajan, T. Computational Fluid Flow & Heat Transfer, Narosa, 1995.
4. Versteeg, H.K. & Malalasekera, W. An introduction to computational fluid Dynamics: The Finite Volume Method, Adison Wesley-Longman, 1995.
5. Roache, P.J. Computational Fluid Dynamics, 2edn, Hermosa, 1982.
6. Hornbeck, R.W. Numerical Marching Techniques for Fluid Flows with Heat Transfer NASA, SP-297, 1973.
7. Hoffmann Klaus. A., Computational Fluid Dynamics for Engineers-Volume I, Engineering Education System, Wichita, 1993.

ELECTIVE I

Course Code: ME 16303 **L-T-P-C**
Course Title: INTRODUCTION TO ROBOTICS **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (11 hours)
Brief History, Types and applications of robots. Present status and future trends in robotics, Overview of robot subsystems. Challenges in robotics, Characteristics of robots, Robot configurations and concept of work space, Types of actuators and sensors in robotics, Types of grippers.

Module 2 (10 hours)
Introduction to Manipulator Kinematics, Position and orientation of rigid bodies, Planar and spatial mechanism description, Homogenous transformations, Denavit - Hartenberg (DH) notation, Forward and inverse kinematic analysis, Examples.

Module 3 (11 hours)
Linear and rotational velocity of rigid bodies, Velocity propagation from link to link, Jacobians, Singularities, Static forces in manipulators, Jacobians in force domain, Cartesian transformation of

velocities and static forces. Forward and Inverse Dynamics, Lagrangian and Newton – Euler_s formulation methods, Examples.

Module 4 (10 hours)
Trajectory Generation, General consideration in path description and generation, Joint space schemes, Collision free path planning, Robot programming. Robot Control, Independent joint control, PD and PID feedback, Issues in nonlinear control, Examples.

References
1. Craig, J.J., Introduction to Robotics, Mechanics and control, 2nd ed., Pearson Education, 1999.
2. Spong, M.W., and Vidyasagar, M., Robot Dynamics and Control, John Wiley and Sons, 1989.
3. Groover, M.P., Weiss, M., Nagel, R.N., and Odrey,N.G., Industrial Robotics: Technology, Programming and Applications, McGraw Hill Publishers, 1986.
4. Paul, R.P., Robot Manipulators Mathematics Programming, Control: The computer control of robotic manipulators, MIT Press, 1979.
5. Schilling, R.J., Fundamentals of Robotics, Analysis and Control, Prentice Hall of India, 1996.
6. Niku, S.B., Introduction to Robotics: Analysis, Systems, Applications, John Wiley and Sons, 2010.

ELECTIVE I

Course Code: ME 16304 **L-T-P-C**
Course Title: GAS DYNAMICS **3-0-0-3**
Pre-requisite: Mechanics of Fluids

Course Content

Module 1 (10 hours)
Basic equations of fluid flow, Reynolds transport equation, Integral and differential formulations - Integral form of the equations of continuity - Momentum - energy equations - use of the integral equations, Differential form of these equations, Stokes postulates and constitutive equations, Navier-Stokes equations and energy equations for Newtonian fluids.

Module 2 (11 hours)
Introduction to compressible flows, Basic concepts - equations for one-dimensional flow through stream tubes - variation of pressure - temperature - density in the atmosphere, Speed of sound , Mach number, Qualitative difference between incompressible, Subsonic and supersonic flows, Karman_s rules of supersonic flows, Characteristic velocities, The adiabatic flow ellipse, Isentropic flow through a duct - criterion for acceleration and deceleration - stagnation quantities - isentropic relations, Use of gas tables and charts, Operation of nozzles at off-design conditions.

Module 3 (11 hours)
Normal shocks in one-dimensional flow - occurrence of shocks - analysis of normal shocks - Prandtl_s equation - Rankine - Hugoniot equation and other normal shock relations - moving shocks, Oblique shocks and expansion waves - oblique shock relations - --M relations - shock polar, Supersonic flow over a wedge - expansion waves - Prandtl- Meyer function - intersection of shocks - detached shocks - Mach deflection - shock expansion theory.

Module 4 (10 hours)

Flow with friction - Fanno lines and Fanno flow relations, Effect of friction on properties - choking, isothermal flows, Flow with simple heat transfer - Rayleigh lines - effect of heat addition - thermal choking, Generalised on dimensional flows - One-dimensional flow with several effects like mass addition - friction and heat transfer.

References

1. Anderson,J.D., *Modern Compressible Flow with Historical Perspective*, 2nd ed., McGraw Hill,1990.
2. Shapiro A.H., *Dynamics and Thermodynamics of Compressible Fluid Flow*, Vol.1, 1st ed., Wiley, 1953.
3. Zuckrow M.J. and Hoffman. J.D., *Gas Dynamics*, Vol.1, Wiley, New York.1976.
4. Zucker,R.D., and Biblarz.O., *Fundamentals of Gas Dynamics*, 2nd ed., John Wiley & Sons, 2002.
5. Liepmann,H.W., and Roshko,A., *Elements of Gas Dynamics*, First South Asian Edition, Dover Publications, 2007.

Course Code: ME 16401 **L-T-P-C**
Course Title: SEMINAR **0-0-2-1**
Pre-requisite: Nil

Course Content

Search technical literature in the form of peer reviewed journals and conference proceedings and identify a current research topic relevant to Mechanical Engineering – Comprehend the topic and prepare a technical report on the topic of presentation in the specified format – Prepare presentation aids and deliver a technical presentation to the class – Appropriate weights will be given for communications skills (both verbal and written) as well as for capacity to impress the audience and ability to handle question and answer session.

Course Code: ME 16201 **L-T-P-C**
Course Title: DYNAMICS OF MACHINARY LABORATORY **0-0-3-2**
Pre-requisite: Dynamics of Machinery

Course Content

1. Conduction of static & dynamic balancing system
2. Determination of gyroscopic effect of a rotating disc
3. Experiment on Watt & Porter governor system
4. Demonstration of various mechanisms
5. Experiment on Proell & Hartnell governor system
6. Demonstration of various gear systems

7. Determination of time period of oscillation and radius of gyration
8. Determination of time period of given torsional pendulum.
9. Determination of the natural frequencies of 2 d.o.f rotor
10. Determination of the time period of undamped free vibration of equivalent spring mass system & study the forced vibration of the beam for different damping constants

Course Code: ME 16202 **L-T-P-C**
Course Title: PRODUCTION ENGINEERING LABORATORY III **0-0-3-2**
Pre-requisite:

Course Content

Experiments in metal cutting: study of chip formation mechanism and influence of various parameters on shear angle; determination of force, temperature, tool life etc. Alignment test of machine tools, other experiments on machine tool /machining (study of machine tool rigidity & vibration etc.). Study and operation of gear generating machines, auto-screw machine, broaching machine, cylindrical grinding machine, NC/CNC Machines; Introduction to machining center etc.; study of non-conventional machining.

Semester VII							
Sl No	Code	Subject	L	T	P	Credit	Category
1	HS 17101	Principle of Management & Entrepreneurship	2	0	0	2	HL
2	ME 17101	Refrigeration and Air Conditioning	3	0	0	3	DCS
3	ME 17102	Operations Research	3	0	0	3	DCS
3	ME 173xx	Elective II	3	0	0	3	DE
4	ME 17201	Heat Engines Laboratory	0	0	3	2	DCS
5	ME 17202	Metrology and Instrumentation Laboratory	0	0	3	2	DCS
6	ME 17401	Minor Project	0	0	3	2	DCS
7	ME 17402	Industrial Internship	-	-	-	1	DCS
8	ME 17403	Comprehensive Viva	-	-	-	1	DCS
Total			11	0	9	19	

Semester VII

Course Code: ME 17101 **L-T-P-C**
Course Title: REFRIGERATION AND AIR CONDITIONING SYSTEMS **3-0-0-3**
Pre-requisite: Thermal Engineering I

Course Content

Module 1 (6 Hours)
Principles of refrigeration – Carnot refrigeration cycle – Various methods of producing cold, Performance parameters – capacity – Coefficient of performance (COP), Refrigeration systems – Vapour compression system –Classification of Vapour absorption system – Air cycle refrigeration – Steam jet refrigeration – thermo electric cooling and magnetic refrigeration, Introduction to liquefaction systems Cascading – simple Linde Hampson system – Claude cycle liquefier.

Module 2 (10 Hours)
Vapour compression refrigeration system – theoretical and practical cycles – simple and multi-pressure systems – thermodynamic analysis, System components – Compressors – Reciprocating compressors – single and multistage compressors – work of compression – effect of clearance – effect of inter-cooling – optimum pressure ratio – efficiencies – rotary compressors – screw type and vane type compressors – hermetic, semi hermetic and open compressors, condensers – water cooled and air cooled condensers – evaporative condensers, expansion devices – capillary tube – constant pressure expansion valve – thermostatic expansion valve – float valve, evaporators – natural,

Module 3 (6 Hours)

Vapour absorption system – principle of operation of aqua – ammonia and lithium bromide – water systems – electrolux system – comparison between vapour compression and absorption systems, Refrigerants – thermodynamic, physical and chemical properties of refrigerants – Selection criteria of refrigerants, designating refrigerants.

Module 4 (10 Hours)
Psychrometry – psychrometric processes – Requirement of air conditioning – human comfort – comfort chart and limitations – effective temperature – factors governing effective temperature – design considerations – inside design condition, ventilation standards, Applied psychrometry, summer air conditioning processes, winter air conditioning processes, round the year air conditioning systems

Module 5 (10 Hours)
Cooling load calculations – various heat sources – solar load – equipment load – infiltration air load – duct heat gain – fan load – moisture gain through permeable walls and fresh air load, design of air conditioning systems – Duct design – equal friction – static regain and velocity reduction methods – distribution systems – insulation, central and unitary systems. Air conditioning equipments and control systems – air filters – humidifiers – fan – blowers – control systems for temperature and humidity – noise and noise control.

References

1. Stoecker, W.F., Refrigeration & Air Conditioning, McGraw Hill, New York, 1958.
2. Stoecker, W.F., & Jones J.W., Refrigeration & Air Conditioning, McGraw Hill, New York, 1982.
3. Dossat, Refrigeration & Air Conditioning, 2nd ed., Wiley Eastern Limited, New Delhi, 1989.
4. Jordan & Priester, Refrigeration & Air Conditioning, 2nd ed., Prentice Hall India Pvt. Ltd, 1985.
5. Arora,C.P., Refrigeration & Air Conditioning, Tata McGraw Hill, New Delhi, 1995.
6. Stoecker W.F., Principles of Air Conditioning, Industrial Press, New York, 1968.
7. Laub, Heating & air conditioning of Buildings, Holt, Rinehart & Winston, New York, 1963.
8. Kell & Marting, Air conditioning & Heating of Buildings, Baltonworth, New York, 1995.
9. Carrier_s Handbook for Design of Unit Air Conditioners, McGraw Hill Book Co, New York, 1965.
10. Threlkeld, J. L., Thermal Environmental Engineering, 2nd ed., Prentice Hall, 1970. 11. Norman C. Harris, N. C., Modern Air Conditioning Practice, 3rd ed., McGraw Hill, 1985.
12. Levenhagen, J. L., Spethmann, D. H., Heating Ventilating and Air Conditioning Controls and Systems, McGraw Hill1, 1993.
13. Carrier Design hand book
14. ASHRAE hand book

Course Code: ME 17102 **L-T-P-C**
Course Title: OPERATIONS RESEARCH **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (12 hours)
An overview of operations research modelling approach, Basic linear algebra – matrices and systems of linear equations – linear dependence and linear independence, Mathematical formulation of linear programming problems, Graphical solution, Theory of simplex method, The simplex algorithm, Artificial starting solution – M-method - two phase method, Alternative optimal solutions, Unboundedness, Degeneracy.

Module 2 (9 hours)
Duality in linear programming – Primal-dual relationships – Economic interpretation of duality, Transportation problems – formulation and solution, Assignment problems – formulation and solution.

Module 3 (9 hours)
Game Theory – two-person zero-sum games – saddle points, Games with mixed strategies – graphical solutions procedure – solving by linear programming.

Module 4 (12 hours)
Dynamic programming – characterization – Bellman_s principle of optimality – problems with a finite number of concentric decisions, Queuing theory – generalized Poisson queuing model – steady state solution of single server models for infinite queue size and finite queue size.

References

1. Taha, H.A., Operations Research: An Introduction, 8th ed., Pearson Education, Inc., 2008.
2. Hillier, F. S., and Lieberman, G. J., Introduction to Operations Research, 8th Ed., Tata McGraw Hill, 2005.
3. Ravindran A., Philips, D., and Solberg, J. J., Operations Research: Principles and Practice, 2nd ed., John Wiley & Sons Inc., 1989.
4. Hadley, G., Linear Programming, Addison Wesley Narosa, Narosa Publishing House, 1987.
5. Vohra N.D., Quantitative Techniques in Managements, McGraw Hill Education, 2009.

ELECTIVE II

Course Code: ME 17301 **L-T-P-C**
Course Title: AERODYNAMICS **3-0-0-3**
Pre-requisite: Fluid Mechanics

Course Content

Module 1 (11 hours)
Equations for incompressible inviscid flows, Fluid circulation and rotation – vorticity - Kelvin_s theorem - velocity potential - stream function - equation of a stream line - complex potential, Blasius theorem for force and moment on bodies, Elementary flow patterns and their superposition.

Module 2 (11 hours)
Flow past a cylinder - Magnus effect - Kutta condition - Vortex theory of lift. Conformal transformation, The Joukowski transformation - lift on arbitrary cylinder, Aerodynamic center,

Pitching moment.

Module 3 (10 hours)
Aerofoils - low speed flows over aerofoils - the vortex sheet, Thin aerofoil theory -symmetric aerofoil, Tear drop theory, Camber line at zero angle of attack, Characteristics of thin aero foils, Motion in three dimensions, Flow past slender bodies.

Module 4 (10 hours)
Finite wings - downwash and induced drag - Prandtl-Lachester theory - Biot- Savart law, General series solution, Glauret method, Multhop_s method, Horseshoe effects, Ground effects, Linerai compressible flows in two dimensions - flow past a wavy wall, Similarity rules, Aerofoil in compressible flows.

References

1. Anderson ,J.D., *Fundamentals of Aerodynamics*, 5th ed., McGraw Hill, New York, 1998
2. Kuethe,A.M., and Chow,C., *Foundations of Aerodynamics*, Fourth Edition, Wiley Eastern, New Delhi, 1986.
3. Katz,J.,and Plotkin,A., *Low Speed Aerodynamics*, McGraw Hill, New York, 1991.
4. Houghton,E.L., and Brock,A.E., *Aerodynamics for Engineering Students*, Edward Arnold, London, 1960.

ELECTIVE II

Course Code: ME 17302 **L-T-P-C**
Course Title: AUTOMOBILE ENGINEERING **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (9 Hours)
Constructional details of engines - engine parts - piston - different types - piston rings cylinder block - cylinder head - gudgeon pin - connecting rod - bearing bushes - different type of bearings, Cooling system- purpose of cooling - types of cooling systems - air cooling - water cooling - radiator - types of radiators - constructional details - thermostat - temperature indicators.

Module 2 (13 Hours)
Lubrication - purpose of lubricating systems - grading of oils - oil pumps - oil filters - oil pressure indicators, Fuel systems - fuel system components - fuel tank - fuel filters and screens - fuel gauges - fuel pumps, Carburetors - idle and low speed circuits - high speed part load circuit - full power circuit - choke, Electronic fuel injection system, Gasoline Direct injection system, Air assisted fuel injection system, Diesel injection system - Common rail Direction Injection system, Ignition system - Battery and coil ignition - Electronic Ignition system - Distributor less Ignition system.

Module 3 (12 Hours)

Transmission - clutch - types of clutches - single and multi plate clutches - centrifugal clutch, Fluid coupling, Torque converter, Gear box - sliding mesh - constant mesh - synchro mesh, Propeller shaft, Universal coupling, Differential, Axle - semi floating - three - fourth floating - fully floating, Brakes - mechanical and hydraulic brakes - vacuum - servo and air brakes - components of braking systems and their functions - constructional details, Anti lock braking system. Steering mechanism - steering geometry - steering gears - worm and wheel gears - power assisted steering.

Module 4 (8 Hours)
Vehicle body terminology, Chassis and suspension - chassis lay out, Independent suspension - Road springs - Shock absorbers - torsion bars, Air suspension systems, Wheels - tyres and tubes, Starting mechanism - starter drives - over running clutch. Electrical equipments - battery - battery charging - charging circuit – regulators. Air pollution and control - Pollution rating - Catalytic converters, Exhaust Gas circulation, Turbocharger.

References

1. Joseph Heitner, *Automotive mechanics Principles and Practices*, 2nd ed., D. Van Nostrand Company, 1967.
2. Newton. K and Steeds.W., *The Motor Vehicle*, The English Language Book Society and Newnes Butterworth, London, 1972.
3. William H Crouse and Donald L Anglin, *Automotive Mechanics,* 10th ed., Pearson Higher Education, 1993.
4. William H Crouse and Donald L Anglin, *Automotive engine,* 8th ed., McGraw-Hill, 1994.
5. William H Crouse and Donald L Anglin, *Automotive fuel - lubricating and cooling systems.* 6th ed., McGraw- Hill, 1981.
6. William H Crouse and Donald L Anglin, *Automotive chassis and body.* 5th ed., McGraw-Hill, 1975.

ELECTIVE II

Course Code: ME 17303 **L-T-P-C**
Course Title: ENGINEERING OPTIMIZATION **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (10 hours)
Introduction – engineering applications of optimization, Statement of an optimization problem, Classification of optimization problems, Linear Programming, Mathematical formulations, Graphical solution, Simplex method, Artificial variable technique – M-method – two-phase method, Duality theory, Sensitivity analysis.

Module 2 (10 hours)
Integer programming, Mathematical formulations, Zero-one problems – additive algorithm, Gomory‗s cutting plane algorithm, Branch and bound algorithm, All integer primal algorithm, All integer dual algorithm, Mixed integer programming – cutting plane algorithm and Bender‗s partitioning algorithm.

Module 3 (10 hours)

Travelling Salesman Problem, Mathematical formulations, Branch and bound algorithms, Heuristics – nearest neighbourhood algorithm – pairwise-interchange heuristic – three-opt heuristic – twice around the tree heuristic and its performance, Vehicle routing problem – optimal solution and heuristic solutions, Network optimization models, Terminology of networks, Minimum spanning tree problem, Shortest-path problem, Maximum flow problem, Minimum cost flow problem, Network simplex method.

Module 4 (12 hours)
Non-linear programming, Formulations, General non-linear programming problem, Unconstrained optimization problem – necessary and sufficient conditions for extrema, Constrained optimization with equality constraints – Lagrangean method, Constrained optimization with inequality constraints – Kuhn-Tucker conditions, Quadratic programming – Wolfe‗s modified Simplex method.

References

1. Srinivasan, G., *Operations Research – principles and applications*, 2nd ed., Prentice-Hall of India, New Delhi, 2010.
2. Hillier, F.S., and Lieberman, G.J., *Introduction to Operations Research*, 8th ed., Tata McGraw-Hill, New Delhi, 2010.
3. Ravindran A., Philips, D.T., and Solberg, J.J., *Operations Research: Principles and Practice*, 2nd ed., John Wiley & Sons, 1987.
4. Taha, H.A., *Operations Research: An introduction*, 6th ed., Prentice-Hall of India, New Delhi, 1997.
5. Winston, W.L., *Operations Research: Applications and Algorithms*, Duxbury Press, 1993.
6. Rao, S.S., *Optimization: Theory and Applications*, 2nd ed., Wiley Eastern, 1994.

ELECTIVE II

Course Code: ME 17304 — **L-T-P-C**
Course Title: INTRODUCTION TO TURBULENCE — **3-0-0-3**
Pre-requisite: Nil

Module 1 (8 hours)
Introduction to turbulent flow, Characteristics of turbulent flow, laminar turbulent transition, Origin of Turbulence, Wall bounded Turbulence and free turbulence. Classification of Turbulence, Isotropic and anisotropic Turbulence, Time Mean motion and Fluctuations, Length scales, velocity Scales, Time scales and Kolmogorov scales, Intensity of Turbulence and Degree of Turbulence.

Module 2 (14 hours)
The Governing equations of Turbulent flow, The N-S equations in Rectangular and Cylindrical Co-ordinates, Time averaging of the N-S equations, Reynolds Stresses, Significance of Reynolds stress, the concept of Eddy Viscosity. Turbulent Boundary-Layer equations, concept of Order of magnitude and its application to Boundary layer equations on a flat plate, Boundary conditions, Laminar sub-layer, Universal Velocity profile on a flat plate, rectangular duct and circular pipes and friction factors.

Module 3 (8 hours)

The concept of vorticity dynamics, Energy producing Large eddies and dissipative eddies, vortex stretching, Concept of energy cascading, Kolmogorov Energy spectrum.
Developing and Fully Developed Turbulent Flow in a pipe for Moderate Reynolds Number, variation of friction factors and shear stresses.

Module 4 (12 hours)
Shear stress models, Prandtl's Mixing length Hypothesis, The eddy viscosity model, The two equation k-ϵ, k-ϖ model, The wall function conception, Solution methodology of k-ϵ, k-ϖ model**.**

Text Books

1. H. Tennekes and J.L. Lumley, 1987, *A First Course in Turbulence,* The MIT Press, Cambridge, Massachusetts, and London, England.
2. P.K. Kundu and I.M. Cohen, 2002, *Fluid Mechanics*, Academic Press (An Imprint of Elsevier Science, USA.
3. S.B. Pope*, Turbulent Flows*, 2000, Cambridge University Press, UK.
4. G. Biswas and V. Eswaran, 2002, *Turbulent Flows: Fundamentals, Experiments and Modeling*, Narosa Publishing House, New Delhi, India.
5. *The Theory of Homogeneous Turbulence,* By G. Batchelor, Cambridge University Press
6. *Incompressible Flow*, By R. Panton, J. Wiley

L-T-P-C
Course Code: ME 17202 **L-T-P-C**
Course Title: METROLOGY AND INSTRUMENTATION LABORATORY 0-0-3-2
Pre-requisite: Metrology and Instrumentation

Course Content

1. Calibration and determination of uncertainties of the following:

(a) Strain gauge load cells (b) Bourdon tube pressure gauge (c) LVDT (d) Thermocouple (e) Tachometers using stroboscopes, etc.
2. Measurement of thread parameters using Universal Measuring Microscope, three wire method, thread pitch micrometer
3. Evaluation of straightness using autocollimator, spirit level
4. Measurement of tool angles of single point tool using TMM
5. Measurement of gear parameters using Profile projector
6. Study and measurement of surface finish using surface roughness tester
7. Study and measurements with CMM
8. Experiments on limits and fits
9. Study and use of ultrasonic flaw detector
10. Exercises on measurement system analysis
11. Study and making measurements with thread pitch micrometer, disc micrometer, thread pitch gauge, height gauge,

Course Code: ME 17401 **L-T-P-C**
Course Title: MINOR PROJECT **0-0-3-2**
Pre-requisite:

Course Content

Students undertake project work to develop the skill and aptitude of problem-solving. The project work is divided into two parts: Minor and Major. The Minor project is to be undertaken in the VII Semester. Students will choose an area of their interest in consultation with a faculty member of the department, who will act as the Supervisor. The area of interest could be confined to his/her discipline or may be interdisciplinary. The project work will involve all or some of the following processes: identification of problem, study of related literature, data collection and analysis, theoretical formulation, fabrication, experimentation and result analysis. The preliminary work such as problem identification through literature survey, field survey etc. and preparation of plan of execution should be complied in the form of a report, in the prescribed format/ guidelines. The report, duly certified by the Supervisor, should be submitted to the Head of the Department. Progress made by students will be continuously monitored and evaluated as per the approved procedure.

Course Code: ME 17402 **L-T-P-C**
Course Title: INDUSTRIAL INTERNSHIP **0 0 0 1**
Pre-requisite:

Course Content

Summer Internships offer students personal and real world spirits and exposes to an actual working life, an experiential foundation to their career choices and the chance to build valuable business networks. Under this programme each student undergoes training in an Industry for a minimum period of six weeks during the summer vacation after VI Semester. Through the internship students are exposed with the various processes involved at any typical industrial unit such as, operating procedure, construction processes, management procedures etc. and have the opportunity to relate with the knowledge they acquired in the classroom. Students execute a small project based on any of the above mentioned aspects under the supervision ofcompetent personnel in the industry and a faculty member of the university. After completion of the Internship, students are required to prepare a report, based on the activities performed during the internship, as per the prescribed format/ guidelines. The report should be certified by the Supervisors, and presented in the form of a seminar in the VII Semester.

Evaluation of the Summer Internship will be done as per the approved procedure.

Course Code: ME 17403 **L-T-P-C**
Course Title: COMPREHENSIVE VIVA VOCE **0 0 0 1**
Pre-requisite:

Course Content

The knowledge gained by the students during their B.Tech programme will be evaluated through a Comprehensive Viva Voce Test in the VII Semester. The test will cover the entire syllabi of the B.Tech degree programme. Preparation for the Comprehensive Viva Voce Test will also help the students in their placement activities. The evaluation will be done as per the approved procedure.

Semester VIII							
Sl No	**Code**	**Subject**	**L**	**T**	**P**	**Credit**	**Category**
1	HS 18101	Engineering Economics	2	0	0	2	HL
2	ME 183xx	Elective III	3	0	0	3	DE
3	ME 183xx	Elective IV	3	0	0	3	DE
4	ME 18401	Major Project	0	0	9	6	DCS
Total			8	0	9	14	

Semester VIII

ELECTIVE III

Course Code: ME 18301 **L-T-P-C**
Course Title: FLUID POWER CONTROLS **3-0-0-3**
Pre-requisite: Fluid Mechanics

Course Content

Module 1 (10 Hours)
Introduction to oil hydraulics and pneumatics, their advantages and limitations, ISO symbols and standards in Oil Hydraulics and pneumatics, Recent developments, applications, Basic types and constructions of Hydraulic pumps and motors, Ideal pump and motor analysis, Practical pump and motor analysis, Performance curves and parameters.

Module 2 (11 Hours)
Hydraulic Actuators, Hydraulic control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves, Series and parallel pressure compensation flow control valves, Flapper valve Analysis and Design, Analysis of valve controlled and pump controlled motor, Electro-hydraulic servo valves-specifications, selection and use of servo valves.

Module 3 (11 Hours)
Electro hydraulic servomechanisms – Electro hydraulic position control servos and velocity control servos, Nonlinearities in control systems (backlash, hysteresis, dead band and friction nonlinearities). Basic configurations of hydraulic power supplies – Bypass Regulated and Stroke Regulated Hydraulic Power Supplies, Heat generation and dissipation in hydraulic systems: Design and analysis of typical hydraulic circuits, Use of Displacement – Time and Travels-Step diagrams: Synchronization circuits and accumulator sizing. Meter - in, Meter - out and Bleed-off circuits: Fail Safe and Counter balancing circuits.

Module 4 (10 Hours)
Components of pneumatic systems: Direction, flow and pressure control valves in pneumatic systems, Development of single and multiple actuator circuits, Valves for logic functions: Time delay valve, Exhaust and supply air throttling, Examples of typical circuits using Displacement – Time and Travel-Step diagrams, Will-dependent control, Travel-dependent control and Timedependent control, combined control, Program Control, Electro-pneumatic control and air hydraulic control, Applications in Assembly, Feeding, Metalworking, materials handling and plastics working.

References

1. Joji,P., Pnumatic controls, Wiley India Pvt. Ltd., 2008.
2. Anthony Esposito., Fluid Power with applications, Pearson Education.
3. Ernst, W., Oil Hydraulic Power and its Industrial Applications, New York, McGraw Hill. 4. Lewis, E. E., and H. Stern, Design of Hydraulic Control Systems, New York, McGraw Hill.
5. Morse, A. C., Electro hydraulic Servomechanism, New York, McGraw Hill.

6. Pippenger, J.J., and R.M. Koff, Fluid Power Control systems, New York, McGraw Hill. 7. Fitch, Jr., E.C., Fluid Power Control Systems, New York, McGraw Hill.
8. Khaimovitch., Hydraulic and Pneumatic Control of Machine Tools.
9. John Watton., Fluid Power Systems: modeling, simulation and microcomputer control, Prentice Hall Int.
10. Herbert E. Merritt., Hydraulic control systems, John Wilely and Sons Inc.
11. Thoma, Jean U., Hydrostatic Power Transmission, Trade and Technical Press, Surrey, England.
12. Ian Mencal., Hydraulic operation and control of Machine tools, Ronald Press.
13. Sterwart., Hydraulic and Pneumatic power for production, Industrial Press.
14. Hasebrink J.P., and Kobler R., Fundamentals of Pnuematics/electropeumatics, FESTO Didactic publication.
15. Werner Deppert and Kurt Stoll., Pneumatic Control-An introduction to the principles, Vogel – Verlag.
16. Blaine W. Andersen., The analysis and Design of Pneumatic Systems, John Wiley and Sons, Inc.
17. Blackburn, J.F., G. Reethof, and J.L. Shearer, Fluid Power Control, New York, Technology Press of M. I. T.

ELECTIVE III

Course Code: ME 18302 **L-T-P-C**
Course Title: ADVANCED THERMODYNAMICS **3-0-0-3**
Pre-requisite: Thermodynamics

Course Content

Module 1 (10 hours)
General principles of classical thermodynamics postulational approach basic postulates conditions of equilibrium fundamental equations equations of state, Euler equation, Gibbs-Duhem equation, Multi-component simple ideal gases.

Module 2 (10 hours)
Reversible processes maximum work theorem alternate formulation energy minimum principle, Legendre transformations, Extremum principles in the Legendre transformed representation, Thermodynamic potentials and Massieu functions.

Module 3 (10 hours)
Maxwell relations and Jacobian methods, Procedure to reduction of derivatives, applications, Stability criteria of thermodynamic systems, First-order phase transition, single component and multi-component systems, Gibbs phase rule phase diagram for binary systems.

Module 4 (12 hours)
Critical phenomena, Liquid and solid Helium, Nernst postulate, Introduction to irreversible thermodynamics linearised relation Onsager_s reciprocity theorems, Special topics on advanced thermodynamics.

References
1. Callen, H.B., *Thermodynamics and an Introduction to Thermostatics*, Second Edition, John Wiley & Sons, 1985.

2. Rao, Y.V.C., *Postulational and Statistical Thermodynamics*, Allied Publishers, 1994. 3. Zemansky, M.W., Abbot, M.M. and Van Ness, H.C., *Basic Engineering Thermodynamics*, McGraw-Hill, 1987
4. Saad, M.A., *Thermodynamics for Engineers*, Prentice Hall of India, 1987.

ELECTIVE III

Course Code: ME 18303 **L-T-P-C**
Course Title: INDUSTRIAL TRIBOLOGY **3-0-0-3**
Pre-requisite: Fluid Mechanics/ Applied Mechanics of Solids

Course Content

Module 1 (11 hours)
Introduction – Basic equations, Derivation of Reynolds equation, Energy equation, Idealized hydrodynamic bearings, Mechanism of pressure development, Plane slider bearings, Idealized journal bearings, Infinitely long and short bearings.

Module 2 (11 hours)

Finite bearings – performance characteristics – numerical solution, Hydrodynamic instability, Design of journal bearings, Analysis of externally pressurized and gas lubricated bearings.

Module 3 (10 hours)
Costs of wear, Surface topography, Mechanics of contact, Theories of friction, Friction of metals and non-metals, Temperature of sliding surfaces, Stick-slip, Rolling friction.

Module 4 (10 hours)
Wear of metals, Adhesive wear, Abrasive wear, Corrosion and corrosion wear, Erosion, Surface fatigue and impact wear, Wear of elastomers, Wear of ceramics and composite materials, Measurement of friction and wear.

References

1. Majumdar, B.C., *Introduction to Tribology*, 4th ed., A.H. Wheeler, Bangalore, 1978.
2. Pinkus and Sternlincht, *Theory of hydrodynamic lubrication*, John Wiley & Sons, New York, 1961.
3. Moore, D. F., *Principle and Application of Tribology*, Pergamon Press, New York, 1975.
4. Rabinnowicz, E., *Friction and Wear of Metals*, John Wiley & Sons, New York, 1995
5. Johnson, K.L., *Contact Mechanics*, Cambridge University Press, 1985.
6. Thomas, T.R., *Rough Surfaces*, Longman Inc., 1982.

ELECTIVE IV

Course Code: ME 18304 **L-T-P-C**
Course Title: RENEWABLE ENERGY SYSTEMS **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (12 hours)
Introduction – energy problem – finite conventional energy sources – energy and environment– need for renewables and energy efficiency, Solar energy – measurement of solar radiation – estimation of terrestrial solar radiation – methods of solar collection and thermal conversion – thermal analysis of flat plate collectors – testing procedures – solar pond – parabolic collectors – paraboloid dish – central receiver, Energy storage systems, Applications of solar thermal systems – residential water heating – industrial heating – power generation.

Module 2 (10 hours)
Biomass energy systems – biomass conversion routes – combustion – gasification – anaerobic digestion – pyrolysis – cogeneration, Performance analysis and testing, Thermal applications – power generation.

Module 3 (10 hours)
Wind energy conversion – wind distribution – types and operation of wind turbines and their characteristics – generators and control strategies, Small hydro power – classification of hydro turbines – performance analysis – selection and sizing, Ocean thermal energy conversion–power generation options, Wave and tidal energy – systems for power generation.

Module 4 (10 hours)
Economic analysis – calculation of energy cost from renewables – comparison with conventional energy systems, calculation of carbon dioxide reduction – incremental costs for renewable energy options, Introduction to integrated energy systems.

References

1. Sukhatme, S.P., and Nayak, J.K., *Solar Energy-Principles of Thermal Collection and Storage*, 3rd ed., Tata McGraw Hill, 2008.
2. Duffie, J.A., and Beckman, W.A., *Solar Engineering of Thermal Processes*, 3rd ed., Wiley, 2006.
3. Goswami, D.Y., Kreith, F., and Kreider, J.F., *Principles of Solar Engineering*, 2nd ed., Taylor and Francis, 2003.
4. Twidell, J. and Weir T., *Renewable Energy Resources*, 2nd ed., Taylor and Francis, 2006.
5. Boyle, G. (Ed.), *Renewable Energy*, 2nd ed., Oxford University Press, 2004.
6. Deublein, D., and Steinhauser A., *Biogas from Waste and Renewable Resources: An Introduction*, 2nd ed., Wiley, 2010.
7. Rai, G.D *Non-conventional energy sources*,. Khanna Publication
8. Ali Murtaza, *Non-conventional energy System,* Koros
9. Agarwal S.K. *Non-conventional energy Systems,*

ELECTIVE IV

Course Code: ME 18305 **L-T-P-C**
Course Title: CAD/CAM/CIM **3-0-0-3**
Pre-requisite: Nil

Course Content

Module 1 (9 hours)
Introduction to computer graphics, 2D and 3D transformations, Plane and space curves, surface description and generation, CAD/CAM hardware and software, CAD/CAM data exchange and integration.

CNC machine tools, fundamentals of CNC machine tools, constructional features, drives and controls, stepper motors, servo motors, hydraulic systems, feed back devices, counting devices, interpolators linear, circular interpolation and other emerging techniques, adaptive control systems for turning and milling.

Module 3 (11 hours)
CNC manual part programming and computer assisted programming, APT language, geometry, motion and auxiliary statements, macro statements, post processors, CNC programming with interactive graphics, use of various software packages, development of CNC programmes for special problems.

Module 4 (11 hours)
Computer integrated manufacturing systems, material handling and identification technologies, computer aided inspection, group technology, flexible manufacturing systems, industrial robotics and machine vision, rapid prototyping, design for manufacturability, process planning and concurrent engineering, lean production and agile manufacturing.

References

1. David, F.Rogers., & Adams, J.H., *Mathematical Elements of Computer Graphics*, 15 th Reprint, McGraw Hill International, 2008.
2. David, F., Rogers., *Procedural Elements for Computer Graphics*, McGraw Hill International, 1998.
3. Ibrahim., Zeid., *CAD/CAM Theory and Practice*, Tata McGraw Hill publishing company, 1991.
4. Yoram., Koren., *Computer Control of Manufacturing Systems*, Mc Graw Hill Book Company, 1983.
5. Mikell, P. Groover., *Automation, Production Systems, and Computer Integrated Manufacturing*, Pearson Education, 2008.
6. Mehta, N.K., *Machine Tool Design & Numerical Control*, 2 nd ed., Tata McGraw Hill, 2005.
7. Bolton. W., *Mechatronics, Electronic Control Systems in Mechanical Engineering*, Addison Wesley Longman Limited, 2003.
8. HMT Limited, *Mechatronics*, 17 th Reprint, Tata McGraw Hill Publishing Company Limited, 2008.
9. Fu., K.S. Gonzalez., R.C., and Lee., C.S.G , Robotics*, Control, Sensing, Vision and Intelligence* , McGraw Hill International, 1987

<u>ELECTIVE IV</u>

Course Code: ME 18306 **L-T-P-C**
Course Title: ADVANCED MANUFACTURING PROCESSES **3-0-0-3**
Pre-requisite: basic Manufacturing Processes

<u>Course Content</u>

Module-1 (23 hrs)
Advanced Machining Processes: Introduction, Process principle, Material removal mechanism, Parametric analysis and applications of processes such as ultrasonic machining (USM), Abrasive jet machining (AJM), Water jet machining (WJM), Abrasive water jet machining (AWJM), Electrochemical machining (ECM), Electro discharge machining (EDM), Electron beam machining (EBM), Laser beam machining (LBM) processes

Module-2 (5 hrs)
Advanced Casting Processes: Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting

Module-3 (5 hrs)
Advanced Welding Processes: Details of electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW)

Module-4 (5 hrs)
Advanced Metal Forming Processes: Details of high energy rate forming (HERF) process, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Stretch forming, Contour roll forming

Module-5 (4 hrs)
Cutting Edge Manufacturing Processes: MEMs fabrications. Lithography, Wet etching process, Dry etching process, Bonding methods.

<u>References:</u>
1. "Materials and Processes in Manufacturing" (8th Edition), E. P. DeGarmo, J. T Black, R. A. Kohser, Prentice Hall of India, New Delhi (ISBN 0-02-978760).
2. "Manufacturing Science" A. Ghosh, and A. K. Mallik, Affiliated East-West Press Pvt. Ltd. New Delhi.
3. "Nontraditional Manufacturing Processes", G.F. Benedict, Marcel Dekker, Inc. New York (ISBN 0-8247-7352-7).
4. ―VLSI Fabrication Principles – Silicon and Gallium Arsenide‖, Sorab K Gandhi, John Wiley & Sons, New Delhi.

Course Code: ME 418401 **L-T-P-C**
Course Title: MAJOR PROJECT **0-0-9-6**
Pre-requisite: Nil

Course Content

After completion of the Minor Project, students shall undertake the Major Project in the VIII Semester. The idea conceived in the Minor Project shall be executed in this semester under the supervision of the faculty member. Students shall complete the practical aspect of the project. Thereafter they will prepare a report, as per the prescribed format/ guidelines, incorporating the results, their analysis and interpretation. The report, duly certified by the Supervisor, should be submitted to the Head of the Department.

Progress made by the student will be continuously monitored and evaluated as per the approved procedure.