1st Semester				
Sl. No.	**Subject Code**	**Subject Name**	**L-T-P**	**Credit**
Theory Subjects				
1	MA11101	Mathematics I	3-1-0	4
2	CY11101	Engineering Chemistry	3-0-0	3
3	CY11102	Health, Safety and Environment	2-0-0	2
4	CS11101	Computer Programming and Problem Solving	2-0-0	2
5	CS11102	Introduction to Computer Systems	2-0-0	2
6	HS11101	English Language and Literature	2-1-0	3
Practical and Sessional Subjects				
7	CS11201	Computer Programming Laboratory	0-0-4	2
8	CY11201	Engineering Chemistry Laboratory	0-0-2	1
9	ME11202	Engineering Graphics	0-0-3	2
10	ME11203	Mechanical Workshop	0-0-2	1
		Total Credits	**14-2-11**	**22**

Course Description

Course Title: ENGINEERING GRAPHICS **L-T-P-C**
Course Code: ME11202 **0-0-3-2**
Pre-requisite: Nil

Course Content

1. **Introduction:** Overview of the course, Examination and Evaluation patterns.
2. **Lines Lettering and Dimensioning**: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales, and Curves.
3. **Orthographic projection**: Principles of Orthographic Projection, Projections of Points, Straight Lines and traces, Projections of Laminas, Projections of Solids.
4. **Development of Surfaces:** Draw the development of surfaces for Prisms, Cylinders, Pyramid and Cones.
5. **Section of Solids**: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section. Development of truncated objects.
6. **Isometric views**: Isometric axis, Isometric Planes, Isometric View, Isometric projection.

Text Books/ References

1. **Bhatt N. D,** Elementary Engineering Drawing, Charotar Publishing House, Anand, 2002.
2. **Dhawan, R. K.,** A Textbook of Engineering Drawing, S. Chand Publishing, 2012.
3. **Narayana K L & Kannaiah P**, Engineering Graphics, Tata McGraw Hill, New Delhi,1992.
4. **Luzadder W J,** Fundamentals of Engineering Drawing, Prentice Hall of India, New Delhi, 2001.
5. **Venugopal K**, Engineering Drawing & Graphics, New Age International Pvt. Ltd., New Delhi, 1994.

Course Title: MECHANICAL WORKSHOP **L-T-P-C**
Course Code: ME11203 **0-0-2-1**
Pre-requisite: Nil

Course Content

1. **Lathe Practice:** Study the different types lathe operations, Exercise- step turning, tapper turning, facing, groove making, thread cutting and knurling operation.
2. **Grinding:** Study of grinding wheel, Surface grinding, up grinding and down grinding, Spark out, Exercise- Making a flat surface by using surface grinder.
3. **Smithy/Foundry:** Study of tools, forging of square or hexagonal prism/ chisel/bolt/ Study of tools, sand preparation, moulding practice, Casting and Pattern making.
4. **Milling**: Milling job, slot cutting, key channel cutting, up milling and down milling.
5. **Drilling**: Study of drilling accessories and instruments.

Text Books/ References

1. **Hajra Choudhury.** Workshop Technology Vol 1 & 2, Media Promoters & Publishers Pvt. Ltd, Bombay, 2004
2. **Chapman W.A.J.,** Workshop Technology. Parts 1 & 2, 4th Edition, Viva Books P. Ltd., New Delhi, 2002
3. **Miami,** Welding Handbook. American Welding Society, 2000
4. Metals Handbook. Vol 6, Welding, Brazing & Soldering. Metals Park, Ohio, American Society of Metals, 1998

2nd Semester				
Sl. No.	**Subject Code**	**Subject Name**	**L-T-P**	**Credit**
Theory Subjects				
1	MA12101	Mathematics II	3-1-0	4
2	PH12101	Engineering Physics	3-0-0	3
3	ME12101	Engineering Mechanics	3-0-0	3
4	CS12101	Foundation of Computing	3-0-0	3
5	EE12101	Principles of Electrical Engineering	3-0-0	3
6	HS12101	Human Values and Effective Communication	1-2-0	3
Practical and Sessional Subjects				
7	PH12201	Engineering Physics Laboratory	0-0-2	1
8	CS12201	Computing Laboratory	0-0-2	1
9	ME12201	Workshop Practice	0-0-3	2
10	EE12201	Electrical Workshop	0-0-2	1
11	ZZ12401	Behaviour and Discipline	-	Audit
12	ZZ12402	Professional Practice I	0-0-2	Audit
		Total Credits	**16-3-11**	**24**

Course Description

Course Title: ENGINEERING MECHANICS **L-T-P-C**
Course Code: ME12101 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (12 Hours)

Introduction: Concept of force, force system, Fundamental laws and principles, principle of transmissibility, particle, rigid body, accuracy limit and approximations.

Coplanar Concurrent Force System: Resultant of a force system, graphical principles parallelogram law, triangle law, polygon rule, analytical method, conditions of equilibrium, space diagram and free body diagrams, Lami's theorem.

Coplanar Non-Concurrent Force System: Moment of a force, Varignon's theorem, couple, properties of couples, resultant of non-concurrent force system, conditions of equilibrium, equilibrant, equilibrium of two-force system and three-force system, types of supports, types of loads.

Concept of Friction: Laws of dry friction, angle of friction, coefficient of friction, belt friction. Problems related to equilibrium of coplanar force system with friction, ladder problems, belt friction problems.

MODULE II (10 Hours)

Centroids and Second Moment of Areas:

(a) *Centroid*: Definition of centre of gravity, centroid of area, centroid of line, concept of line of symmetry, location of centroid by direct integration of rectangular, triangular, semi-circular and quarter circular areas, centroid of composite areas.

(b) *Second Moment of Area*: Definition, parallel axis theorem, polar moment of area, radius of gyration, second moment of area by direct integration of a rectangular, triangular, circular, semi-circular and quarter-circular area. Second moment of composite area.

MODULE III (10 Hours)

Kinematics: Definition of kinematics, kinetics, displacement, velocity, acceleration, relationship between them, problems involving variable acceleration, equations of motion under constant acceleration, motion under gravity, projectile motion.

Application of Newton's Second Law: Newton's second law, definition of unit force, problems of rectilinear motion, motion of connected bodies.

MODULE IV (10 Hours)

Application of Work-Energy Principle: Definition of work, energy, power, efficiency, derivation of work-energy equation, problems of rectilinear motion, motion of connected bodies.

Application of Impulse-Momentum Equation: Definition of linear momentum, impulse, derivation of impulse-momentum equation, conservation of linear momentum, problems related to rectilinear motion, motion of connected bodies, conservation of momentum.

Text Books/ References

1. Irving. H. Shames, Engineering Mechanics—Statics and Dynamics, 4th Edition, Prentice Hall of India, 1996.
2. F.P. Beer and E.R. Johnston, Vector Mechanics for Engineers – Statics, McGraw Hill Book Company, 2000.
3. J.L. Meriam and L.G. Kraige, Engineering Mechanics – Statics, John Wiley & Sons, 2002.

Course Title: WORKSHOP PRACTICE **L-T-P-C**
Course Code: ME12201 **0-0-3-2**
Pre-requisite: Nil

Course Content

1. **Introduction to Mechanical Workshop:** Study of Workshop rules and safety considerations in different machinery usages and machine tools.
2. **Carpentry:** Study of tools and joints – planning, chiseling, marking and sawing practice, one typical joint- Tee halving/Mortise and Tenon/ Dovetail
3. **Fitting:** Study of tools- chipping, filing, cutting, drilling, tapping and threading about male and female joints, stepped joints- one simple exercise of single V joint for welding exercise.
4. **Sheet Metal work:** Study of tools, selection of different gauge sheets, types of joints, fabrication of a tray or a funnel
5. **Lathe Exercise:** Study of the basic lathe operations, a simple step turning exercise.
6. **Welding Practice:** Study and practice of manual metal arc welding (MMAW). Exercise of Butt joint/Lap Joint/Corner Joint/Tee Joints.

Text Books/ References

1. **Chapman W.A.J.,** Workshop Technology. Parts 1 & 2, 4th Edition, Viva Books P. Ltd., New Delhi, 2002
2. **Hajra Choudhury**, Workshop Technology Vol 1 & 2, Media Promoters & Publishers Pvt. Ltd, Bombay, 2004
3. **Miami,** Welding Handbook, American Welding Society, 2000.

3rd Semester				
Sl. No.	**Subject Code**	**Subjects**	**L-T-P**	**Credit**
Theory Subjects				
1	ME13101	Fluid Mechanics	3-0-0	3
2	ME13102	Elements of Solid Mechanics	3-0-0	3
3	ME13103	Thermodynamics	3-0-0	3
4	ME13104	Materials Science and Metallurgy	3-0-0	3
5	ME13105	Mathematics III	3-1-0	4
6	EE13106	Electrical Machines and Measurements	3-0-0	3
Practical and Sessional Subjects				
7	ME13201	Fluid Mechanics Laboratory	0-0-2	1
8	ME13202	Elements of Solid Mechanics Laboratory	0-0-2	1
9	ME13203	Machine Drawing	0-0-3	2
10	EE13205	Electrical Machines and Measurements Laboratory	0-0-2	1
11	ZZ13201	Professional Practice II	0-0-2	Audit
		Total Credits	**18-1-11**	**24**

Course Description

Course Title: FLUID MECHANICS **L-T-P-C**
Course Code: ME13101 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (8 Hours)

Basic Concepts, Fluid Statics and Fluid Kinematics, Fluid dynamics - concept of the control volume - Integral and differential forms of the continuity - momentum equations, Illustrative examples for the conservation of mass, linear and angular momentum

MODULE II (12 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 III (12 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 IV (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.

Text Books/ References

1. **Massey, B. S., Jhon Ward-Smith,** Mechanics of Fluids, CRC Press, 9th Edition, 2011.
2. **Som, S. K., Biswas, G. and Chakraborty, S.** Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill Education, 3rd Education, 2017.
3. **Ojha, C.S.P., Berndtsson, R., Chandramouli, P.N.,** 'Fluid Mechanics and Machinery', Oxford Higher Education, Seventh impression, 2015.
4. **Cengel, Y.A, Cimbala, John, M.,** Fluid Mechanics, Fundamentals and Applications', 7th Ed. Tata Mc Graw Hill, New Delhi, 2009.
5. **Shames, I.H.,** 'Mechanics of fluids', Mc Graw Hill Book Co., 1986.
6. **White, F.M**., 'Fluid Mechanics', 6th Ed., Tata Mc Graw Hill, New Delhi, 2009.
7. **Muralidhar, K. and Biswas, G.,** Advanced Engineering Fluid Mechanics, Narosa Publishing House, 2001.

Course Title: ELEMENTS OF SOLID MECHANICS **L-T-P-C**
Course Code: ME13102 **3-0-0-3**
Pre-requisite: Engineering Mechanics

Course Content

MODULE I (8 Hours)

Simple stresses and strains: Mechanical properties of materials, concept of stresses and strains, stress-strain diagrams and salient points, Hooke's law, Elastic constants and their relationship, bars of varying cross sections, elongation due to self-weight, thermal stresses, compound bars.

MODULE II (12 Hours)

Bending moment and shear force diagrams: Definition of bending moment and shear force at a section, sign convention, relationship between bending moment, shear and load intensity, SFD and BMD for statically determinate beams subjected to point loads, uniformly distributed loads and uniformly varying loads, and couples, loading diagram corresponding to the given shear diagrams

Stresses in homogeneous beams: Simple bending theory, assumptions, derivation of pure bending equation, definition of section modulus, moment of resistance, modulus of rupture, derivation of shear stress in beams, shear stress distribution across rectangular, triangular and circular sections.

MODULE III (10 Hours)

Deflection of beams: Governing differential equation for deflection of straight beams having constant flexural rigidity, double integration and Macaulay`s methods for slopes and deflection. Energy methods: principle of superposition; work done by forces- elastic strain energy stored; Maxwell- Bettis theorem; Castigliano`s theorems; strain energy expressions; fictious load method; statically indeterminate problems, Torsion of circular shafts: Definition of pure torsion, assumptions, derivation of pure equation, transmission of power, polar modulus of section, modulus of rupture in torsion, strength and stiffness of solid and hollow shafts.

MODULE IV (12 Hours)

Combined stresses: Stress at a point, principal stresses and principal planes for general two dimensional stress systems, application to beams and shafts, concept of equivalent bending moment and torque.

Thin and Thick cylinders: Classification, stresses and deformations in thin cylinders subjected to internal pressure, derivation of lame's equation for thick cylinder.

Axially loaded compression members: Classification, definition of effective length, slenderness ratio, critical load, derivation of Euler's equation for a column hinged at both ends, Rankine-Gordon formula, problems.

Text Books/ References

1. **E.J.Hearn** Mechanics of Materials, Pergamon Press
2. **S.S.Bhavikatti** Strength of Materials, Vikas Publications
3. **Ferdinand L Singer,** Strength of Materials, Harper & Raw
4. **B.S.Basavarajaiah,** Strength of Materials, Khanna Publishers

Course Title: THERMODYNAMICS **L-T-P-C**
Course Code: ME13103 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (10 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 II (8 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 III (8 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 IV (10 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 V (6 Hours)

Gas power cycles – Otto, Diesel. Basic Rankine and Refrigeration cycles. Thermodynamic property relations – the Maxwell relations – the Clapeyron equation –Clausius- Clapeyron equation, general relations for du, dh, ds, C_V, and C_P, The Joule-Thomson coefficient, The h , u , and s of real gases.

Text Books/ 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 Title: MATERIALS SCIENCE AND METALLURGY **L-T-P-C**
Course Code: ME13104 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (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 II (10 Hours)

Solidification of metals - cooling curves, nucleation - homogeneous and heterogeneous nucleation, supercoiling, 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 III (11 Hours)

Deformation of metals - cold working, hot working, annealing of a cold worked article - recovery, recrystallization 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, normalizing, hardening, TTT diagram, tempering, hardenability, Jominy test. Surface hardening - flame hardening, induction hardening, Case hardening - carburizing, nitriding, cyaniding, etc. Metallic Coatings, hard facing, metal cladding, anodising, diffusion coatings.

MODULE IV (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.

Text Books/ 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.

Course Title: Mathematics-III	**L-T-P-C**
Course Code: ME13105	**3-1-0-4**
Pre-requisite: Mathematics-II	

Course Content

MODULE I (12 Hours): Complex Analysis
Complex functions, Derivative, Analytic function, Cauchy- Reimann equations, Line integral in the Complex plane, Cauchy's Integral Theorem, Cauchy's Integral formula, Derivatives of analytic functions. Taylor series and Maclaurin's series, Laurent's series, Singularities, Zeros and Residue.

MODULE I (09 Hours): Matrix Theory
Types of matrices, Complex matrices, Characteristic polynomials, Eigen value, Eigen Vector, Caley Hamillton theorem and its applications, Reduction to diagonal form, Linear transformation,

MODULE I (09 Hours): Optimization Techniques
Introduction to Linear Programming Model, Graphical method, Simplex Method, Nonlinear Optimization, Lagrange Method.

MODULE IV (10 Hours): Statistics
Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means.

Text Books/ References

Text Books:

1. **S.C. Gupta & V. K. Kapoor,** Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 11th edn. New Delhi-2011
2. **J. W. Brown and R.V. Churchill,** Complex Variables and Applications, 7th edn., McGraw Hill, 2004.
3. **K. Hoffman & R Kunze**, Linear Algebra, 2th edn. Pearson Education India, 2003.
4. **H. A. Taha,** Operation Research: An Introduction, 9th edition, Dorling Kindersley, Pearson.

Reference Books:

1. **Kanti Swarup, P.K. Gupta & Man Mohan.,** Operational Research, Sultan Chand & Sons New Delhi.
2. **Dennis G. Zill and Patrick D. Shanahan**, A first course in Complex analysis with applications, 2nd edn., Jones and Bartlett, 2010.

3. **Erwin Kreyszig,** Advanced Engineering Mathematics, 9th edn., Wiley India, 2009.
4. **Levin R. I. & Rubin D. S.,** Statistics for Management, 7th edition, PHI, New Delhi, 2000.
5. **S.M. Ross,** Introduction to Probability and statistics for Engineers, 3rd edition, Academic Press, Delhi, 2005.
6. **S Ponnusamy,** Foundations of Complex Analysis, 3nd edn., Norosa Publishing house New Delhi-2009.

Course Title: ELECTRICAL MACHINES AND MEASUREMENTS **L-T-P-C**
Course Code: EE13106 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (12 Hours): Electrical Measurements

General principles of measurements, units, dimensions, standards and calibration of meters, various types of Galvanometers – principle of operation, direct deflecting instruments - moving coil, moving iron, dynamometer, induction; extension of instrument ranges, measurement of current, voltage and resistance, Wheatstone bridge, Kelvin double bridge, insulation resistance, earth resistance, localization of cable fault by Murray and Varley loop tests. Measurement of power and energy –power in single phase ac circuits, power in three phase AC circuits, measurement of energy using single-phase energy meter.

MODULE II (10 Hours): DC Machines

Electromechanical energy conversion principles, types of machines, basics of rotating machines - emf and torque equation, losses and efficiency. DC machines - principle of operation generators and motors –characteristics, starter, speed control, load test, applications.

MODULE III (10 Hours): Transformers

Construction of single phase transformer, principle of operation, equivalent circuit, regulation and efficiency, OC and SC tests –introduction to three phase transformer.

MODULE IV (10 Hours): AC Machines

Alternators - types, principle of operation; synchronous motors - principle of operation, starting, applications, induction motors - principle of operation, types, tests, performance characteristics, starting, and speed control schemes, applications. Special machines - universal motors, stepper motors, servo motors, tachogenerators.

Text Books/ References

1. **Clayton and Hancock,** Performance & Design of DC Machines, CBS.
2. **A.S. Langsdorf,** Principles of DC Machines, McGraw-Hill.
3. **M. G. Say**, Performance & Design of AC Machines, Pitman.
4. **A.S. Langsdorf,** Theory of AC Machinery, McGraw-Hill.
5. **A. K. Sawhney,** Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai & Sons.
6. **Soni, Gulpta and Bhatnagar,** A course in Electric Power, Dhanpat Rai & Sons.

Course Title: FLUID MECHANICS LABORATORY **L-T-P-C**
Course Code: ME13201 **0-0-2-1**
Pre-requisite: Fluid Mechanics

Course Content

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 - venturi meter- 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.

Course Title: ELEMENTS OF SOLID MECHANICS LABORATORY **L-T-P-C**
Course Code:ME13202 **0-0-2-1**
Pre-requisite: Elements of Solid Mechanics

Course Content

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 Title: MACHINE DRAWING **L-T-P-C**
Course Code: ME 13203 **0-0-3-2**
Pre-requisite: Engineering Drawing

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.

Text Books/ 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 Title: ELECTRICAL MACHINES AND MEASUREMENTS LABORATORY **L-T-P-C**
Course Code: ME13205 **0-0-2-1**
Pre-requisite: Electrical Machines and Measurements

Course Content

1. Measurement of power in a single-phase AC circuit
2. Measurement of power in a 3 phase AC circuit using two-wattmeter method.
3. Measurement of energy using single-phase energy meter and verification by power/time measurements.
4. Determination of the efficiency and regulation of single-phase transformer.
5. Open circuit and short circuit tests on a single-phase transformer.
6. Study of starters for 3 phase induction motor.
7. 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.

Course Title: PROFESSIONAL PRACTICE II **L-T-P-C**
Course Code: ZZ13401 **0-0-2-0**

Course Content

1. Understanding technology historically
- Emergence and growth of technology in response to collective needs
- Commodity production and expansion of trade; economic imperatives for technological advancement.

2. Technology and work
- Technology and industrial production: fordism and post-fordism
- Division of labour and social identities : race, ethnicity, gender

3. Technology, cultural globalization and global consumerism
- Computer, Media and Culture
- Information and Communication Technology. Role of communication technology: five components of communication, pyramid of communication.
- Global television and American cultural imperialism.

4. Internet and Community
- Understanding of Community in the information age
- The virtual individual and the virtual social
- Power and cyberspace

5. The Ecology Approach
- The natural world and the built environment; nature, man and science; eco-systems and eco-feminism
- Technology and sustainable development.

Each student will be required to submit to the class teacher at least four different articles containing about 2000 words on four engineering topics assigned by the class teachers, and will be required to give concise talks on those topics in the class according to the direction of the class teacher, and will have to participate in the discussion on such talks of the other students also. The result of those assignments will be considered as that of practical work. There will be no written examination for this course.

4th Semester				
Sl. No.	**Subject Code**	**Subjects**	**L-T-P**	**Credit**
Theory Subjects				
1	ME14101	Fluid Machinery	3-0-0	3
2	ME14102	Kinematics of Machinery	3-0-0	3
3	ME14103	Heat Transfer	3-0-0	3
4	ME14104	Casting, Welding and Forming	3-0-0	3
5	ME14105	Industrial Engineering	3-0-0	3
6	ME14106	Metrology and Instrumentation	3-0-0	3
Practical and Sessional Subjects				
7	ME14201	Fluid Machinery Laboratory	0-0-2	1
8	ME14202	Heat Transfer Laboratory	0-0-2	1
9	ME14203	Casting, Welding and Forming Laboratory	0-0-2	1
10	ME14204	Computer Graphics Laboratory	0-0-2	1
11	ZZ14201	Professional Practice III	0-0-2	Audit
12	ZZ14202	Behavior and Discipline	-	Audit
		Total Credits	**18-0-10**	**22**

Course Description

Course Title: FLUID MACHINERY **L-T-P-C**
Course Code: ME14101 **3-0-0-3**
Pre-requisite: Fluid Mechanics

Course Content

MODULE I (10 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 II (10 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 cavitation in turbines.

MODULE III (12 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, Cavitation in pumps, pump and system characteristics, operating points

MODULE IV (10 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.

Text Books/ References

Text Books

1. **Ojha, C.S.P., Berndtsson, R., Chandramouli, P.N.,** 'Fluid Mechanics and Machinery', Oxford Higher Education, Seventh impression, 2015.
2. **Jagdish Lal**, Hydraulic Machines, 6th ed., Metropolitan book Co. private Ltd. New Delhi.

References

1. **Shepherd D.G.,** Principles of Turbo machinery, Macmillan Company, New York, 1956.
2. **Stepanof, A.J.,** Centrifugal and Axial Flow Pumps, 2nd edition, John Wiley & Sons Inc., New York, 1957.
3. **Dixon, S.L, Hall, C.A.,** Fluid Mechanics and Thermodynamics of Turbo machinery, Pergamon Press, 4th ed., 1998.

Course Title: KINEMATICS OF MACHINERY **L-T-P-C**
Course Code: ME14102 **3-0-0-3**
Pre-requisite: Engineering Mechanics

Course Content

MODULE I (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 II (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 III (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 IV (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 closureequation technique – Freudenstein's equation, Case studies in synthesis of mechanisms.

Text Books/ References

1. **Ghosh, A, and Mallik, A.K.,** Theory of Mechanisms and Machines, 3rd ed., Affiliated EastWest Press, 1998.
2. **Rattan, S.S.,** Theory of Machines, 3rd ed., Tata McGraw-Hill, 2009.
3. **Uicker, J.J.Jr., Pennock, G.R., and Shigley, J.E.,** Theory of Machines and Mechanisms, 3rd ed., Oxford University Press, 2009.
4. **Sandor, G.N., and Erdman, A.G.,** Advanced Mechanism Design: Analysis and Synthesis, Vol. I & II, Prentice-Hall of India, 1988.
5. **Mabie, H.H., and Reinholtz, C.F.,** Mechanisms and Dynamics of Machinery, 4th ed., John Wiley & Sons, 1987.
6. **Waldron, K.J., and Kinzel, G.L.,** Kinematics, Dynamics and Design of Machinery, John Wiley & Sons, 2004.
7. **Norton, R.L.,** Design of Machinery, Tata McGraw-Hill, 2004.
8. **Martin, G.T.,** Kinematics and Dynamics of Machines, McGraw-Hill, 1969.
9. **Nikravesh, P.E.,** Planar Multibody Dynamics, CRC Press, 2008.

Course Title: HEAT TRANSFER **L-T-P-C**
Course Code: ME14103 **3-0-0-3**
Pre-requisite: Thermodynamics

Course Content

MODULE I (10 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 II (12 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 III (10 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 IV (10 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.

Text Books/ References

1. **S.C. Arora, S. Domkundwar& A.V. Domkundwar** "A course in Heat and Mass Transfer" Dhanpat Rai& Co. (P) Ltd., Delhi.
2. **Holman, J.P., Heat Transfer**, 9th ed., Tata McGraw Hill, 2005.
3. Fundamental of Engineering Heat and Mass Transfer (S.I Units), **R. C Sachdeva**, second edition, New age International (P) limited publishers.
4. Heat Transfer, **P.S. Ghoshdastidar.**
5. **Incorpera, F.P. and De Witt, D.P.,** Fundamentals of Heat and Mass Transfer, John Wiley.

6. **Kreith, F**., Heat Transfer, International Text Book Company. 4 Gebhart, B., Heat Transfer, McGraw Hill.
7. Heat and Mass Transfer, **O.P. Single**
8. Heat and Mass Transfer**, Yunus A Cengel & Afshin J Ghajan**
9. Heat and Mass Transfer, **P.K. Nag**

Course Title: CASTING, FORMING AND WELDING **L-T-P-C**
Course Code: ME14104 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (14 Hours)

Theory of casting and solidification, Fluidity of liquid metals; Technology of patternmaking and mould making, Pattern allowances, testing of moulding sand, cores; Gating system design, riser Design, different methods of calculating riser volume, feeding distance calculations; Theory of melting and production of ferrous and non-ferrous materials, casting design, Casting defects

MODULE II (14 Hours)

Mechanical fundamentals of metalworking: Concept of stress and strain, stress and strain tensors, Hydrostatic and deviatory stresses, Flow curve; Yield criteria for ductile materials, plastic stress strain relationships, classification of metalworking, mechanics of metalworking; Analysis and classification of rolling and forging processes, Force calculations in rolling and forging processes; Analysis and classification of Extrusion process, Analysis of wire, rod and tube drawing processes, Forming defects

MODULE III (14 Hours)

Classification of welding processes, Thermal effects in welding, Basic metallurgy of fusion welds, Heat affected zone in welding; Principles of welding processes: Arc welding, Gas metal arc welding, Solid state welding, Resistance welding, Soldering, Brazing and adhesive bonding; Residual stresses in welding, Methods of measurement of residual stresses in welding, Welding distortion and its types, Methods of reducing residual stresses and distortion in welding; Weldability of materials: Introduction and assessment of weldability, Test for weldability, Weldability of ferrous and non-ferrous materials.

Text Books/ References

Text Books

1. **Rao, P.N.,** Manufacturing Technology (Foundry, Forming and Welding), Tata McGraw Hill, 1987.
2. **Ghosh, A., and Mallik, A.K.,** Manufacturing Science, Affiliated East west Press Ltd, 2001.

References

1. **Heine, R., Loper, C., and Rosenthal, P.,** Principles of Metal Casting, Tata McGraw Hill, 2004.
2. **Little, R.,** Welding and welding Technology, Tata McGraw Hill, 2004.

3. **Kalpak Jain, S.,** Manufacturing Engineering & Technology, Addison Wesley Longman Limited, 1995.
4. **Flemings, M.C.,** Solidification Processes, McGraw Hill, American Welding Society, Welding Hand Book.
5. **Doyle, L.E.,** Manufacturing Processes and Materials for Engineers, 3rd ed., Prentice Hall of India, 1984.
6. **Taylor, H.F., Flemings, M.C., and Wulff, J**., Foundry Engineering, 1st ed., John Wiley & Sons Inc, 1959.
7. **Metals Hand Book – Vol. 5**, Welding Institute of Metals, USA.

Course Title: INDUSTRIAL ENGINEERING **L-T-P-C**
Course Code: ME14105 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (10 Hours)

Organization: Factory system, principles of organization, types of organization and their selection. Introduction to work study: Scientific management – Productivity - Advantages of work study to Management. Method Study: Introduction - Process charts, Critical Examination, Identification of key activities on process charts, Diagrams and Templates, Therbligs, Micro motion analysis, Memo motion study.

MODULE II (8 Hours)

Principles of Motion Economy: Related to human body, work place, equipment. Work Measurement: Work measurement techniques –Performance Rating, Standard data, work sampling, predetermined motion work system. Ergonomics and its industrial application. Industrial Relations: Labour welfare, wage and incentives, absenteeism and labour turnover.

MODULE III (12 Hours)

Quality and Quality Control: Introduction, evolutions of quality, Quality costs, statistical quality control; Control charts for variables and attributes: X bar, R, p and c charts; Sampling, concepts and scope of TQM and QFD.

MODULE IV (12 Hours)

Reliability- Introduction, importance & definition, Bath tub curve, System Reliability. PERT and CPM- Introduction, Network analysis, forward pass and backward pass, Float calculation, PERT calculation for social project, Risk estimation. Value Analysis and Value Engineering (VA/VE): Definitions and Benefits.

Text Books/ References

1. **M. Telsang,** *Industrial Engineering and Production Management*, 3/e, S. Chand Publishers.
2. **O.P. Khanna,** *Industrial Engineering and Management,* 2018-2019, Dhanpat Rai Publications.
3. **V. Ravi,** *Industrial Engineering and Management,* 2015, PHI learning Private Limited.

4. **Philips E Hicks,** *Industrial Engineering and Management,* March 1 1994McGraw-Hill Education
5. **T. R. Banga** and **S.C. Sharma,** *Industrial Engineering and Management,*2008, Khanna Publisher.
6. **Ralph M. Barnes**, *Motion and Time Study-Design and Measurement of Work*, 7th ed. Wiley India Pvt. Ltd.
7. **M. Mahajan,** *Industrial Engineering and Production Management,* 2005, DhanpatRai Publication.
8. **P. Ghosh and S. Nandan,** *Industrial Relation and Labour Law*, 1st ed. McGraw-Hill Education

Course Title: METROLOGY AND INSTRUMENTATION **L-T-P-C**
Course Code: ME14106 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (8 Hours)

Introduction to Metrology: Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Classification and selection of measuring instruments and systems. Accuracy, precision and errors in measurement. System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars (Numerical), standardization.

Linear Measurement and angular measurements: Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112). Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness.

MODULE II (8 Hours)

System of Limits, Fits, Tolerance and Gauging: Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.

Comparators: Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electrical principles, LVDT, Pneumatic- back pressure gauges, Solex comparators and optical comparators- Zeiss ultra-optimeter.

MODULE III (10 Hours)

Measurement of screw thread and gear: Terminology of screw threads, measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods, best size wire. Screw thread gauges, Tool maker's microscope.

Gear tooth terminology, tooth thickness measurement using constant chord method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error.
Advances in metrology: Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructional features, applications.

MODULE IV (8 Hours)

Measurement systems and basic concepts of measurement methods: Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement, classification of errors. Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers.

MODULE V (8 Hours)

Force, Torque and Pressure Measurement: Direct methods and indirect method, force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments. Pressure measurement, principle, use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.
Measurement of strain and temperature: Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit, orientation of strain gauges for force and torque.
Strain gauge based load cells and torque sensors. Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, optical pyrometer.

Text Books/ References

Text Books

1. Mechanical Measurements, **Beckwith Marangoni and Lienhard**, Pearson Education, 6th Ed., 2006.
2. Engineering Metrology, **R.K. Jain,** Khanna Publishers, Delhi, 2009.

Reference Books

1. Engineering Metrology and Measurements, **Bentley**, Pearson Education.
2. Theory and Design for Mechanical Measurements, III edition, **Richard S Figliola, Donald E Beasley, WILEY** India Publishers.
3. Engineering Metrology, **Gupta I.C.,** Dhanpat Rai Publications.
4. Deoblin's Measurement system, **Ernest Deoblin, Dhaneshmanick**, McGraw –Hill.
5. Engineering Metrology and Measurements**, N.V.Raghavendra and L.Krishnamurthy,** Oxford University Press.

Course Title: FLUID MACHINERY LABORATORY **L-T-P-C**
Course Code: ME14201 **0-0-2-1**
Pre-requisite: Fluid Mechanics/Fluid Machinery

Course Content

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 Title: HEAT TRANSFER LABORATORY **L-T-P-C**
Course Code: ME14202 **0-0-2-1**
Pre-requisite: 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 Title: CASTING, WELDING AND FORMING LABORATORY **L-T-P-C**
Course Code: ME14203 **0-0-2-1**
Pre-requisite: Casting, Welding and Forming

Course Content

Introduction to Foundry-Patterns, pattern allowances-ingredients of moulding sand and melting furnaces. Foundry tools and their purposes, Demonstration of mould preparation, Demonstration on sweep pattern and core making in mould preparation Practice – Preparation of mould by using split pattern. Study of different hand operated power tools, uses and their demonstration, Calculate the amount of the clay content in the given moulding sand. Find out the grain fineness number of the given moulding sand. Find out the green shear and green compression strength and shatter index of the given moulding sand Calculate the permeability of the given moulding sand, find out the dry shear and dry compression strength of the given moulding sand, Demonstration casting of at least two products. Practice of all available Bosch Power tools. Rolling, forging, extrusion, punching and blanking. Drawing process.

Testing of greensand properties - Greensand mould design & making process with complete gating system including its testing through a CAE software for thermal aspects- Making of a shell using shell moulding machine-Study of defects in castings-Making of lap joint by resistance welding process and its strength evaluation-Study of bead geometry in arc welding process for its strength & micro-structure-Determination of weld characteristics using DC and AC power sources -Study of butt joint strength evaluation by GMAW process-Welding of Aluminium with GTAW process-Preparation of moulds of simple objects like

flange, gear V- grooved pulley etc.-Process parameters of gas welding, TIG, MIG & Spot welding Jobs-Use of Die and Mould for Sheet Metal Fabrication- Simulation of manufacturing processes on various tools.

Course Title: COMPUTER GRAPHICS LABORATORY **L-T-P-C**
Course Code: ME14204 **0-0-2-1**
Pre-requisite: Machine Drawing

Course Content

Introduction to CAD, basics of AUTOCAD, draw commands, Layout and sketching.

2D – Modelling and isometric drawings of Flange Coupling, Plummer Block, Screw Jack, Lathe Tailstock, Stuffing Box, Non-Return Valves, Connecting Rod by using AUTOCAD

Introduction of 3D Modelling Software creation of following Machine Elements using 3D Modelling Software- Nut and Bolt, Gears, Universal Joint, Cotter joint and Knuckle joint

Course Title: PROFESSIONAL PRACTICE III **L-T-P-C**
Course Code: ZZ14201 **0-0-2-0**

Course Content

1. Understanding technology historically
   - Emergence and growth of technology in response to collective needs
   - Commodity production and expansion of trade; economic imperatives for technological advancement.
2. Technology and work
   - Technology and industrial production: fordism and post-fordism
   - Division of labour and social identities : race, ethnicity, gender
3. Technology, cultural globalization and global consumerism
   - Computer, Media and Culture
   - Information and Communication Technology. Role of communication technology: five components of communication, pyramid of communication.
   - Global television and American cultural imperialism.
4. Internet and Community
   - Understanding of Community in the information age
   - The virtual individual and the virtual social
   - Power and cyberspace
5. The Ecology Approach
   - The natural world and the built environment; nature, man and science; eco-systems and eco-feminism
   - Technology and sustainable development.

Each student will be required to submit to the class teacher at least four different articles containing about 2000 words on four engineering topics assigned by the class teachers, and will be required to give concise talks on those topics in the class according to the

direction of the class teacher, and will have to participate in the discussion on such talks of the other students also. The result of those assignments will be considered as that of practical work. There will be no written examination for this course.

Course Title: BEHAVIOUR AND DISCIPLINE **L-T-P-C**
Course Code: ZZ14202 **0-0-0-0**

Course Content

This course will provide instruction on educational terminology, assessment and diagnoses, research-based theory and application strategies for classroom management, discipline and social skill development for students with disabilities, especially individuals with behavioural and/or emotional challenges. Students will learn how to identify appropriate prevention and intervention strategies, including functional analysis, applied behavioural analysis, positive behavioural supports and other research-based approaches. In addition, students will learn how to apply these models, using research-supported strategies and practices. Students will learn the legal protections afforded students presenting emotional/behavioural characteristics.

5th Semester				
Sl. No.	**Subject Code**	**Subjects**	**L-T-P**	**Credit**
Theory Subjects				
1	HS15101	Engineering Economics	2-0-0	2
2	ME15101	Dynamics of Machinery	3-0-0	3
3	ME15102	Thermal Energy Conversion	3-0-0	3
4	ME15103	Machining Science	3-0-0	3
5	ME15104	Machine Design I	3-0-0	3
6	ME15105	Control Theory and Applications	2-0-0	2
Practical and Sessional Subjects				
7	ME15201	Kinematics and Dynamics of Machinery Laboratory	0-0-2	1
8	ME15202	IC Engine Laboratory	0-0-2	1
9	ME15203	Machining Science laboratory	0-0-2	1
10	ME15204	Metrology and Instrumentation Laboratory	0-0-2	1
11	ZZ15201	Professional Practice IV	0-0-2	Audit
		Total Credits	**16-0-10**	**20**

Course Description

Course Title: ENGINEERING ECONOMICS **L-T-P-C**
Course Code:HS15101 **2-0-0-2**
Pre-requisite: Nil

Course Content

MODULE I (08 Hours)

Introduction to basic economics and Engineering economy- How people make decisions, interact and how the economy works, Relationship among Science, Engineering, Technology and Economic Development, Utility Analysis, Laws of Demand and Supply, Market Equilibrium; Elasticity of demand its measurements and application.

MODULE II (08 Hours)

Engineering Production function- Output Elasticity, Homogeneous production function, technological progress, Production Function in the short and long run, difference between firm and industry, Economies of scale, Concepts of Cost and revenue Analysis, Break-Even analysis.

MODULE III (08 Hours)

Meaning of Market, Structure of markets: Pricing and Output Determination in Perfect competition, Monopoly, Monopolistic and Oligopoly; Macroeconomic concepts-National Income, Business Cycles, Inflation, Deflation, Stagflation; Monetary and Fiscal Policy.

MODULE IV (07 Hours)

Performance of Indian economy since 1951-Primary Secondary and Tertiary sectors; Economic reforms and liberalization-Indian's growth post liberalization, India's five-year plans, Niti Aayog; International Trade- Foreign Exchange Rate, Balance of Payment.

Text Books/ References

Text Books

1. **Gregory. N. Mankiw**, "Principles of Microeconomics", Cengage Learning, 7th Edition, 2013.
2. **Rudiger Dornbusch and Stanley Fischer, "**Macroeconomics", McGraw-Hill Europe. 11th Edition, 2011.
3. **Jagdish Handa,** "Monetary Economics", Routledge, 2nd Edition, http://dl4a.org/uploads/pdf/Monetary%20Economics.pdf.
4. Engineering Production Functions: A Survey; Author(s): **Sören Wibe;** Source: Economica, New Series, Vol. 51, No. 204 (Nov., 1984), pp. 401-411; Stable URL: https://www.jstor.org/stable/2554225
5. **Lipsey and Chrystal**, "Economics", Oxford University Press, 13th Edition, 2015.

References

1. **Hal R. Varian,** "Intermediate Microeconomics : A Modern Approach", SPRINGER (INDIA) PVT. LTD. India, 8th Edition, 2010.
2. **James M. Henderson and Richard E. Quandt,** "Microeconomic Theory: A Mathematical Approach", McGraw-Hill Book Company, 3rd Edition, 1980.

Course Title: DYNAMICS OF MACHINERY **L-T-P-C**
Course Code:ME15101 **3-0-0-3**
Pre-requisite: Kinematics of Machinery

Course Content

MODULE I (12 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 mechanisms, Flywheels, Dimensions of flywheel rims, Punching press.

MODULE II (14 Hours)

Dynamic analysis of slider crank mechanisms, Velocity and acceleration of a piston, Angular velocity and angular acceleration of connecting rod, Engine force analysis, turning moment on a crank shaft, dynamically equivalent system, Inertia of the connecting rod, turning moment diagram, Fluctuation of energy, balancing of inline engines, Balancing of V- engines, Balancing of Radial engines.

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,

MODULE III (04 Hours)

Gyroscopic Torque (Couple), Gyroscopic effect on Aeroplanes, Gyroscopic effect on Naval ships, Stability of a Two-wheel vehicle. Types of Governors, Watt Governor, Porter Governor, Proell Governor, Hartnell Governor, Inertia Governor, Hunting, Isochronism, Stability, Effort of a Governor, Power of a Governor, Controlling force.

MODULE IV (12Hours)

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. Introduction to Two-degree freedom system, Vibration absorber

Text Books/ References

1. **Ghosh, A, and Mallik, A.K.,** Theory of Mechanisms and Machines, 3d ed., Affiliated East-West Press, 1998.
2. **Rattan, S.S.,** Theory of Machines, 3d ed., Tata McGraw-Hill, 2009.
3. **Uicker, J.J. Jr., Pennock, G.R., and Shigley, J.E.,** Theory of Machines and Mechanisms, 3d ed., Oxford University Press, 2009.
4. **Mabie, H.H., and Reinholtz, C.F.,** Mechanisms and Dynamics of Machinery, 4d ed., John Wiley & sons, 1987.
5. **Holowenko, A.R.,** Dynamics of Machinery, John Wiley & Sons, 1965.
6. **Waldron, K. J., and Kinzel, G. L., Kinematics**, Dynamics and Design of Machinery, John Wiley & Sons, Inc., 2004.
7. **Norton, R.L.,** Design of Machinery, Tata McGraw-Hill, 2004.

Course Title: THERMAL ENERGY CONVERSION **L-T-P-C**
Course Code:ME15102 **3-0-0-3**
Pre-requisite: Thermodynamics, Heat Transfer and Fluid Mechanics

Course Content

MODULE I (10 Hours)

Air standard cycles; fuel-air and real cycles; combustion and abnormal combustion in SI and CI engines and combustion chambers; A/F ratio.

MODULE II (12 Hours)

2S & 4S engines; carburetors and electronically controlled fuel injection systems for SI engines; fuel injection systems for diesel engines; lubrication systems; cooling systems; MPFI, CRDI, HCCI engines; engine testing, performance and exhaust emission characteristics; control of exhaust pollution.

MODULE III (10 Hours)

Turbocharger and Supercharger; EGR; current developments including electronic monitoring and control of engines; introduction to special engines and computer simulation of two stroke & four stroke engines

MODULE IV (10 Hours)

Rankine cycle and modifications; boilers in steam power plant; Gas turbine cycles- Ideal Brayton cycle, actual Brayton cycle, Compressors.

Text Books/ References

1. **Yunus A. Cengel and Michael A. Boles,** Thermodynamics – An engineering approach, 3rd ed., Mc Grawhill Professional, 1998
2. **John B. Heywood,** Internal Combustion Engine Fundamentals, 1st ed., McGraw-Hill, 1998.
3. **Mathur L. and. Sharma R. P, A** Course in Internal Combustion Engines, 7th ed., Dhanpat Rai Publications (P) Ltd., 1999.
4. **Ganehan V,** Internal Combustion Engines, MaGraw Hill Education, 2012
5. **Sajith V and Thomas S,** Internal Combustion Engines, Oxford Inviersity Press, 2017
6. **Domkundwar VM,** A course in Internal Combustion Engines, Dhanpat Rai and Co. 2018
7. **Nag PK**, Engineering Thermodynamics, 5th ed. McGraw Hill Publication, 2013
8. **Nag PK**, Power plant Engineering, Tata McGraw-Hill.
9. **Arora and Domkundwar,** A course in Power Plant Engineering, Dhanpat Rai & Sons.

Course Title: MACHINING SCIENCE **L-T-P-C**
Course Code:ME15103 **3-0-0-3**
Pre-requisite: Nil

Course Content

MODULE I (13 Hours)

Lathes – Classifications, principles of working components, work holding & tool holding devices, operations. Capstan & Turret and other special purposes lathes. Drilling and boring machine -Classifications- principles of working components, work holding & tool holding devices. Shaping-Classifications- principles of working components- quick return and pawl & ratchet mechanisms, operations. Planning, slotting & broaching machines

MODULE II (09 Hours)

Milling – Classifications, principles of working components, operations, indexing mechanism. Gear hobbing, Grinding machines - Classification principles of working components, wheel classifications.

MODULE III (10 Hours)

Special Purposes Machines **-** polygonal turning and drilling deep hole drilling and trepanning - shaped tube electrolytic machining - thread rolling - roller burnishing – electrical discharge wire cutting - thermal deburring - orbital grinding micromachining

MODULE IV (10 Hours)

Introduction to NC & CNC machine tools and manual part programming. Part programming of simple components.
Introduction to non-traditional machining processes – Classifications, EDM, WEDM, ECM, USM, AJM, AWJM, LBM.
Introduction of MEMs fabrications & Additive manufacturing

Text Books/ References

1. Khanna, O.P., and Lal, M., A Text Book of Production Technology, Vol II , Dhanpat Rai & Sons, 1992.
2. Yoram Koren, Computer Control of Manufacturing Systems, McGraw-Hill, 1986.
3. **Choudhry, S.K.H.,** Elements of Work Shop Technology, VoL II, Media Promoters & Publishers, 1994.
4. Production Technology by HMT, Tata McGraw-Hill, 2002.
5. **Kundra, T.K., Rao, P.N., and Tiwari, N.L.K.,** Numerical Control and Computer Aided Manufacturing, Tata McGraw-Hill, 2006.

Course Title: MACHINE DESIGN I **L-T-P-C**
Course Code:ME15104 **3-0-0-3**
Pre-requisite: Engineering Mechanics/ Elements of Solid Mechanics

Course Content

MODULE I (11 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 II (11 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 III (11 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 IV (9 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.

Text Books/ 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.

Course Title: CONTROL SYSTEM **L-T-P-C**
Course Code:ME15105 **2-0-0-2**
Pre-requisite: Principles Electrical Engineering, Fluid Mechanics

Course Content

MODULE I (10 Hours)

Terminology - plant, process, system, disturbances, controlled variable, manipulated variable etc., Block diagram of basic control system, application areas with examples. Classifications of control systems, Concept of superposition for linear systems with examples. Translational and rotational mechanical, electrical, thermal, hydraulic and pneumatic systems, Force voltage and force current analogy, Position servo mechanism. Block diagram and signal flow graph representation of physical systems along with rules, properties, comparison and limitation, Mason's gain formula

MODULE II (10 Hours)

Standard test signals along with examples of their usage, steady state errors for step, ramp and parabolic inputs, analysis of first and second order systems, Transient response specifications with numerical examples, Basic control actions and two position, proportional, PI, PID and rate feedback controllers, Limitations of time domain analysis .Need of frequency response analysis, Sinusoidal response of linear system, methods used in frequency response, Frequency domain specifications.

MODULE III (10 Hours)

Basic elements of hydraulic circuit, Principle used in hydraulic circuit, Sources of hydraulic power, Integral, Derivative, PD & PID controller with its transfer function, Comparison between hydraulic and electrical control system. Basic elements of pneumatic circuit, Difference between pneumatic and hydraulic control systems, Force balance and force distance type controllers, Nozzle-flapper amplifier, PD, PI and PID control system along with its transfer function.

MODULE IV (10 Hours)

Concept of stability, types of stability, Routh's stability criterion, special cases with numerical examples, stability of closed loop system, concept of root locus, open loop and closed loop transfer poles, step by step procedure for root loci, numerical examples. State space representation, state variables, state, state vector, state space, formulation of state space equations for mechanical and electrical systems, advantages over classical technique.

Text Books/ References

1. Modern control theory, **Katsuhiko Ogata**, Pearson Education International, Fifth edition.
2. Control system engineering, **Norman S Nise, John Wiley & Sons**, Inc., Sixth edition.
3. Modern control systems, **Richard C. Dorf, Robert H Bishop,** Pearson Education International, Twelfth edition.
4. Automatic control systems, **Farid Golnaraghi, Benjamin C Kuo, John Wiley & Sons,** Inc., Ninth edition.
5. **J.Nagrath and M.Gopal,"** Control System Engineering", New Age International Publishers, 5th Edition, 2007.

Course Title: KINEMATICS AND DYNAMICS OF MACHINERY LABORATORY **L-T-P-C**
Course Code: ME15201 **0-0-2-1**
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. Determination of the pressure profile of lubricating oil in journal bearing.
7. Study the Analysis of Cam mechanism.
8. Determination the Coriollis component of acceleration.
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
11. Determination of the holding torque of Epicyclic gear train.

Course Title: IC ENGINE LABORATORY **L-T-P-C**
Course Code:ME15202 **0-0-2-1**
Pre-requisite: Thermodynamics, Thermal Energy Conversion, Heat Transfer

Course Content

1. Study the Cut Section Model of Actual Single Cylinder Four Stroke Diesel Engine and Plotting Valve Timing Diagram.
2. Study the Cut Section Model of Actual Single Cylinder Two Stroke Petrol Engine and Plotting Port Timing Diagram.
3. Study the Cut Section Model of Actual Single Cylinder Four Stroke Petrol Engine and Plotting Valve Timing Diagram.
4. Study The Cut Section Model of Four Stroke Four-Cylinder Diesel Engine.
5. Study The Performance Characteristics and Heat Balance Sheet of Single Cylinder Four Stroke Petrol Engine Test Rig

6. Study The Performance Characteristics and Heat Balance Sheet Four Stroke Single Cylinder Diesel Engine Test Rig
7. Calculation of CV of Fuel Using Bomb Calorimeter.
8. Determination of flash point of fuel using Able Flash Point Apparatus.
9. Determination of flash point of fuel using Pensky Marten Flash Point Apparatus.
10. Determinations of flash point & fire point of fuel using Cleveland Flash Point & Fire Point Apparatus.
11. Usage of Thermal Imaging Device.
12. Study The Performance of Rotary Air Compressor.

Course Title: MACHINING SCIENCE LABORATORY **L-T-P-C**
Course Code:ME15203 **0-0-2-1**
Pre-requisite: Machining Science

Course Content

1. Perform facing, plain turning, step turning, taper turning, knurling, drilling, grooving, parting off, thread cutting, chamfering, and other operations in Lathe.
2. Milling operations-slot cutting, gear cutting.
3. Shaping operations- v-slot cutting
4. Grinding operations – surfacing.
5. Demonstration of operations in CNC Lathe and Milling machine.

Text Books/ References

1. Chapman, W.A.J., Workshop Technology Vol II, 4th ed., CBS Publishers & Distributors, 2007.
2. Boothroyd, G., Fundamentals of Metal Machining and Machine Tools, McGraw Hill, 1975.
3. Henry, B.D., Aaron, A., and James, A., Machine Tool Operations, Vol II, 4th ed., Tata McGraw Hill, 1960.
4. Chowdhary, H., Workshop Technology Vol II – Machine Tools, Media Promoters and Publishing.
5. HMT, Production Technology, Tata McGraw Hill, 2004.

Course Title: METROLOGY AND INSTRUMENTATION LABORATORY **L-T-P-C**
Course Code: ME15204 **0-0-2-1**
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
   d. 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 Title: PROFESSIONAL PRACTICE IV **L-T-P-C**
Course Code: ZZ15201 **0-0-2-0**

Course Content

1. Understanding technology historically
   - Emergence and growth of technology in response to collective needs
   - Commodity production and expansion of trade; economic imperatives for technological advancement.
2. Technology and work
   - Technology and industrial production: Fordism and post-Fordism
   - Division of labour and social identities: race, ethnicity, gender
3. Technology, cultural globalization and global consumerism
   - Computer, Media and Culture

- Information and Communication Technology. Role of communication technology: five components of communication, pyramid of communication.
- Global television and American cultural imperialism.

4. Internet and Community

- Understanding of Community in the information age
- The virtual individual and the virtual social
- Power and cyberspace

5. The Ecology Approach

- The natural world and the built environment; nature, man and science; eco-systems and eco-feminism
- Technology and sustainable development.

Each student will be required to submit to the class teacher at least four different articles containing about 2000 words on four engineering topics assigned by the class teachers, and will be required to give concise talks on those topics in the class according to the direction of the class teacher, and will have to participate in the discussion on such talks of the other students also. The result of those assignments will be considered as that of practical work. There will be no written examination for this course.

6th Semester				
Sl. No.	**Subject Code**	**Subjects**	**L-T-P**	**Credit**
Theory Subjects				
1	HS16101	Principles of Management	2-0-0	2
2	ME16101	Machine Design II	3-0-0	3
3	ME16102	Theory of Metal Cutting	3-0-0	3
4	ME16103	Production and Operations Management	3-0-0	3
5	ME16104	Refrigeration and Air-Conditioning	3-0-0	3
6	ME161**	Elective I	3-0-0	3
Practical and Sessional Subjects				
7	ME16201	Metal Cutting Laboratory	0-0-2	1
8	ME16202	Energy Conversion Laboratory	0-0-2	1
9	ME16203	Machine Design Laboratory	0-0-3	2
10	ME16204	Refrigeration and Air-Conditioning Laboratory	0-0-2	1
11	ZZ16201	Professional Practice V	0-0-2	Audit
12	ZZ16202	Behavior and Discipline	-	Audit
		Total Credits	**17-0-11**	**22**

Course Description

Course Title: PRINCIPLES OF MANAGEMENT **L-T-P-C**
Course Code:HS16101 **2-0-0-2**
Pre-requisite: Nil

Course Content

MODULE I (06 Hours)

Introduction of organizations and management, Concept of Industrial Management, Characteristics of Management, Management as an art – profession, Principles of Management, The evolution of management, Organizational environment, , Decision making-types, conditions and decision making process, Decision Making Aids.

MODULE II (08 Hours)

Dimensions of P-O-L-C: Vision & Mission; Strategizing; Goal & Objectives; Organization Design, Culture, Human Resource Management, Understanding Work Teams, Motivation, Leadership and Communication and Interpersonal Skills, foundation of Control.

MODULE III (10 Hours)

Introduction to Functional areas of Management: Operations Management, Marketing Management, Financial Management.

MODULE IV (06 Hours)

Introduction to Entrepreneurship: Starts ups, Prospects & Challenges., Environmental Issues, CSR, Sustainability, The role of statistics for Industrial management: Simple Linear Regression and Correlation- Assumptions and Properties of Least Square Estimator, Its Application by taking industrial data and its interpretations, Statistical Software-Eview to be utilized to solve the industrial problems.

Text Books/ References

Text Books

1. **Koontz, H., and Weihrich, H.,** Essentials of Management: An International, Innovation and Leadership Perspective, 10th ed., McGraw Hill, 2015.
2. **Robbins, SP, Bergman, R, Stagg, I, and Coulter, M,** Management 7, Prentice Hall, 7th edition, 2015.
3. **Richard I Levin, David S Rubin**, Statistical management, 7th Edition, Prentice Hall India, 2011.
4. **Kotler, P., Keller, Kevin Lane Keller et al.** Marketing Management, 3rd Edition, 2016.
5. Eugene F. Brigham and Michael C. Ehrhardt, Financial Mangement: Theory and Practice, South-Western College Pub; 15th Edition, 2016.

References

1. **Mahadevan, B.,** Operations Management, Theory and Practice, Pearson Education Asia,
2. **A. Aswathapa,** Organizational Behaviour, 2010
3. **Robert R. Reeder, Briety & Betty H. reeder,** Industrial Marketing, Prentice Hall of India Pvt. Ltd, New delhi,2008.

Course Title: MACHINE DESIGN-II **L-T-P-C**
Course Code:ME16101 **3-0-0-3**
Pre-requisite: Engineering Mechanics/ Elements of Solid Mechanics

Course Content

MODULE I (12 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 –

MODULE II (6 Hours)

Belt and chain drives of common types- analysis of belt tension – condition for maximum power- pulleys for flat belts- design of flat and V-belt drives – selection of roller chains- chain lubrication.

MODULE III (12 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 III (12 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.

Text Books/ 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. **Juvinall, R.C. and Marshek, K.M.,** Fundamentals of Machine Component design, 3rd ed., John Wiley & Sons, 2000.
6. **Norton, R.L.,** Machine Design, 2nd ed., Pearson Education, 2000.

Course Title: THEORY OF METAL CUTTING **L-T-P-C**
Course Code:ME16102 **3-0-0-3**
Pre-requisite: Machining Science

Course Content

MODULE I (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 II (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 III (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 IV (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.

Text Books/ 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 Title: PRODUCTION AND OPERATIONS MANAGEMENT **L-T-P-C**
Course Code: ME16103 **3-0-0-3**
Pre-requisite: Industrial Engineering

Course Content

MODULE I (12 Hours)

Types of production systems, Modern production management systems, Decisions in production management, Forecasting, Time series analysis – components of time series – moving average – simple exponential smoothing, Simple regression, Error measurement – tracking signal, Material requirement planning (MRP) – technical issues – system dynamics, Basic problem solving and improvement tools, Just-In-Time (JIT) – value added focus – sources of waste – JIT Principles, ERP.

MODULE II (10 Hours)

Inventory control, Functions of inventor, Inventory problem classification, Relevant cost, Selective inventory control, Independent demand systems – deterministic models – sensitivity analysis – quantity discount – batch production – Introduction to probabilistic models, Basic concepts of supply chain management.

MODULE III (10 Hours)

Facilities Planning, Objectives of facility planning, Facilities planning strategies, Assembly chart, Operation process chart, Scrap and equipment estimation, Facility design – management and planning tools – flow, space and activity relationship – flow patterns, Layout planning, Systematic layout planning, Types of layout – process layout – product layout – group technology layout – retail service layout, Reading assignments on method study and time study.

MODULE IV (10 Hours)

Scheduling-Work centre scheduling, Priority Rules and Techniques, Shop Floor control-Gantt chart, Personnel Scheduling In service.

Text Books/ References

1. **Chase, R.B., Shanker, R., Jacobs, F.R. and Aquilano, N.J.,** Production & Supply Management, 12th ed., Tata McGraw-Hill Edition, 2010.
2. **Tersine, R.J.,** Principles of Inventory and Materials management, 4th ed., Prentice-Hall International, 1994.
3. **Vollmann, Berry, Whybark and Jacobs**, Manufacturing Planning and Control for Supply Chain Management,5th ed., Tata McGraw-Hill Edition, 2005.
4. **Tomkins, White, Bozer, Frazelle, Tanchoco and Trevino,** Facility Planning, 2nd ed., John Wiley & Sons, 1996.
5. **Grant, E.L, and Leavenworth, R.S**., Statistical quality Control, 7th ed., McGraw-Hill, 1996.

Course Title: REFRIGERATION AND AIR-CONDITIONING **L-T-P-C**
Course Code:ME16104 **3-0-0-3**
Pre-requisite: Thermodynamics, Heat Transfer and Fluid Mechanics

Course Content

MODULE I (10 Hours)

Introduction to refrigeration and refrigeration; refrigeration cycles; refrigeration systems, VCRS & VARS; actual cycles; system components; compressors; Refrigerant- nomenclature.

MODULE II (10 Hours)

Moist Air & Psychrometric chart; processes in Psychrometric chart, bypass factor; apparatus dew point temperature, SHF; air conditioning systems, summer, winter and year around etc; Human comfort-comfort chart-effective temperature.

MODULE III (10 Hours)

Room load calculation; sources of heat; design of air conditioning systems; duct design-factors and different methods; air distribution method, dampers, grills, AHU, Insulation.

MODULE IV (12 Hours)

Heating systems; warm air systems, hot water systems; Steam heating systems, panel and central heating systems; heat pump circuit and heat sources for heat pump; air conditioning equipment and control systems; Control systems for temperature and humidity, noise control; charging of refrigerant, testing for leakage.

Text Books/ References

1. **Nag PK,** Engineering Thermodynamics, 5th ed. McGraw Hill Publication, 2013
2. **Yunus A. Cengel and Michael A. Boles,** Thermodynamics – An engineering approach, 3rd ed., Mc Grawhill Professional, 1998.
3. **Arora, CP**, Refrigeration & Air conditioning, 3rd ed., (fifteenth reprint) McGraw Hill, 2013.
4. **Dossat RJ,** Refrigeration & Air conditioning, 4th ed., prentice hall, 2015 (Indian Print).
5. **Kell JR and Martin PL,** Air conditioning & Heating of buildings, 6th ed., Architectural Press, 2007.
6. **Domkundwar SA and Arora SC,** A Course in Refrigeration and Air Conditioning, Dhanpat Rai (P) Ltd., New Delhi 1997.
7. **Khurmi RS and Gupta JK**, A Textbook of Refrigeration and Air Conditioning, Revised Edition, S Chand Publications, 2006.

Course Title: METAL CUTTING LABORATORY **L-T-P-C**
Course Code:ME16201 **0-0-2-1**
Pre-requisite: Theory of Metal Cutting

Course Content

1. Study of various types of cutting tools and measurement of tool geometry
2. To Understand the Effect of Chosen Parameters on the type of chip produced
3. Determination of chip-thickness ratio and shear plane Angle During Machining
4. Measurement of cutting forces in turning using Lathe Tool Dynamometer under various cutting conditions
5. To study the Temperature Measurement on chip tool interface
6. To study and understand the effect of a suitable cutting lubricant
7. Design a Jig and Fixture for given component
8. To study different press and design of punch and die, also exercise on strip layout and center of pressure
9. Study of Unconventional Manufacturing Process and simple exercise on metal removal rate.

Course Title: ENERGY CONVERSION LABORATORY **L-T-P-C**
Course Code:ME16202 **0-0-2-1**
Pre-requisite: Thermal Energy Conversion, Fluid Mechanics and Thermodynamics

Course Content

1. Experimentation on centrifugal blower test-rig (variable speed mode).
2. Experimentation on computerized centrifugal blower test-rig (variable speed mode).
3. Study on the cut section model of Lancshire boiler.
4. Study on the cut section model of Babcock & Wilcox boiler.
5. Study on the cut section model of Cochran boiler.
6. Study on the cut section model of Bent tube/ Striling boiler.
7. Assembling and dismantling of a four stroke four-cylinder petrol engine
8. Study on models of different type of clutches used in automobiles.
9. Study on models of universal joints, propeller shaft and differential gearbox
10. Study on models of different types of suspension systems.
11. Study on models of different types of axles.
12. Study on models of braking system.
13. Study on models of electrical circuits used in automobiles.
14. Performance and combustion analysis of VCR multi-fuel engine with open ECU.

Course Title: MACHINE DESIGN LABORATORY **L-T-P-C**
Course Code:ME16203 **0-0-3-2**
Pre-requisite: Machine Design I, Machine Design II

Course Content

1. Review of stress calculation
2. Problems on Static failure theories
3. Problems on Stress concentration and Design for Fatigue
4. Problems on power screws and threaded fasteners
5. Design of threaded joints 6. Design of shafts, keys and couplings
6. Design of Universal Joint (Knuckle Joint and Spigot and Cotter Joint)

Course Title: REFRIGERATION AND AIR CONDITIONING LABORATORY **L-T-P-C**
Course Code:ME16204 **0-0-2-1**
Pre-requisite: Refrigeration and Air Conditioning, Thermodynamics and Fluid Mechanics

Course Content

1. Study the Cut Section model/s Hermetic and Semi-Hermetic Compressors.
2. Study the Cut Section Model of Domestic Refrigerator.
3. Evaluation of COP for Vapour Compression Refrigeration Cycle Test Rig (Manual Mode).
4. Evaluation of COP for Vapour Compression Refrigeration Cycle Test Rig (Computerized Mode).
5. Evaluation of COP for Vapour Absorption Refrigeration Cycle Test Rig.
6. Evaluation of COP, By-pass Factor etc (both heating and cooling coil) for VCRC based Air-conditioning Test Rig.
7. Refrigerant Leak Detection.
8. Study the Performance of Thermo-Electric Refrigerator.

Course Title: PROFESSIONAL PRACTICE V **L-T-P-C**
Course Code:ZZ16201 **0-0-2-0**

Course Content

1. Understanding technology historically
- Emergence and growth of technology in response to collective needs
- Commodity production and expansion of trade; economic imperatives for technological advancement.

2. Technology and work

- Technology and industrial production: fordism and post-fordism
- Division of labour and social identities : race, ethnicity, gender

3. Technology, cultural globalization and global consumerism

- Computer, Media and Culture
- Information and Communication Technology. Role of communication technology: five components ofcommunication, pyramid of communication.
- Global television and American cultural imperialism.

4. Internet and Community

- Understanding of Community in the information age
- The virtual individual and the virtual social
- Power and cyberspace

5. The Ecology Approach

- The natural world and the built environment; nature, man and science; eco-systems and eco-feminism
- Technology and sustainable development.

Each student will be required to submit to the class teacher at least four different articles containing about 2000 words on four engineering topics assigned by the class teachers, and will be required to give concise talks on those topics in the class according to the direction of the class teacher, and will have to participate in the discussion on such talks of the other students also. The result of those assignments will be considered as that of practical work. There will be no written examination for this course.

Course Title: BEHAVIOR AND DISCIPLINE **L-T-P-C**
Course Code:ZZ16202 **0-0-0-0**

Course Content

This course will provide instruction on educational terminology, assessment and diagnoses, research-based theory and application strategies for classroom management, discipline and social skill development for students with disabilities, especially individuals with behavioral and/or emotional challenges. Students will learn how to identify appropriate prevention and intervention strategies, including functional analysis, applied behavioral analysis, positive behavioral supports and other research-based approaches. In addition, students will learn how to apply these models, using research-supported strategies and practices. Students will learn the legal protections afforded students presenting emotional/behavioral characteristics.

7th Semester				
Sl. No.	**Subject Code**	**Subjects**	**L-T-P**	**Credit**
Theory Subjects				
1	ME171**	Elective II (Project Related Subject)	3-0-0	3
2	ME171**	Elective III	3-0-0	3
3	ME171**	Elective IV	3-0-0	3
4	ME171**	Elective V	3-0-0	3
Practical and Sessional Subjects				
5	ME17201	Advanced Manufacturing Processes Laboratory	0-0-2	1
6	ME17202	Design and Analysis Laboratory	0-0-2	1
7	ME17203	Elective Laboratory	0-0-2	1
8	ME17204	Practical Training Evaluation	0-0-2	2
9	ME17205	Project Part I	0-0-2	4
		Total Credits	**12-0-10**	**21**

Course Description

Course Title: ADVANCED MANUFACTURING PROCESSES LABORATORY **L-T-P-C**
Course Code:ME17201 **0-0-2-1**
Pre-requisite: Casting Forming and welding/Machining Science

Course Content

The Advanced Manufacturing Processes Laboratory provides the state-of-the-art facilities for realizing next generation products and educating the next generation of engineers who believe in working closely with the industry to advance the manufacturing field. The focus of the lab is on both process as well as system level manufacturing solutions. The current research activities include manufacturing process and system simulation, process planning, production planning, manufacturability analysis, and nanomaterial processing. The course include injection molding, CNC machining, ceramic gel casting, in-mold assembly, layered manufacturing, power processing, high temperature sintering, and resin transfer molding. The major equipment that would be studied in this laboratory are CNC Machining center including CNC lathe tool, Tool post Dynamometer, Tool makes microscopes, surface profilers, 3-D printers.

Course Title: DESIGN AND ANALSIS LABORATORY **L-T-P-C**
Course Code:ME17202 **0-0-2-1**
Pre-requisite: Machine Design I/II and Machine Drawing

Course Content

Develop programs for transformations in design software; Develop programs for synthetic curves in design software; Assembly modelling in design software, generating, editing and modifying drawings in design software; Introduction to developing program for finite element analysis in computing software: Solution of Trusses problems**,** Beams and Frames problems, Vibration problems using the developed code; Introduction to mechanical finite element analysis software is used to simulate computer models*:* Solution of problems on Trusses, *Beams and Frames,* Triangular element etc. using simulation software; Solution of 3D analysis problems using design and simulation software; Case studies and working on projects.

Course Title: PRACTICAL TRAINING EVALUATION **L-T-P-C**
Course Code:ME17204 **0-0-2-2**

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 of competent 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 Title: PROJECT PART I **L-T-P-C**
Course Code:ME17205 **0-0-2-4**

Course Content

Students undertake project work to develop the skill and aptitude of problem-solving. 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.

8th Semester				
Sl. No.	**Subject Code**	**Subjects**	**L-T-P**	**Credit**
Theory Subjects				
1	ME181**	Elective VI (Project Related Subject)	3-0-0	3
2	ME181**	Elective VII	3-0-0	3
3	ME181**	Elective VIII	3-0-0	3
Practical and Sessional Subjects				
4	ME18201	CAM Laboratory	0-0-2	1
5	ME18202	Computational Thermo-Fluid Analysis	0-0-2	1
6	ME18203	Project Part II	0-0-4	6
7	ZZ18201	Behavior and Discipline	-	Audit
		Total Credits	**9-0-8**	**17**

Course Description

Course Title: CAM LABORATORY **L-T-P-C**
Course Code:ME18201 **0-0-2-1**
Pre-requisite: CAD/CAM

Course Content

1. Basic concepts of CAD/CAM.
2. Study and development of 2 D model on CAD software (Solid Edge).
3. Study and development of 3 D model on CAD software (Solid Edge).
4. Study of Part Programming fundamentals and G & M codes.
5. Manual part programming for CNC lathe and simulation.
6. Manual part programming for NC milling and simulation.
7. Part program generation by CAM software (UICAM).
8. Study of Group technology and part families.
9. Study of Computer Aided Process Planning.
10. Study of Flexible Manufacturing System.
11. A Case study on 'CIM model for a modern industry CNC application'.

Course Title: COMPUTATIONAL THERMO-FLUID ANALYSIS **L-T-P-C**
Course Code:ME18202 **0-0-2-1**
Pre-requisite: Thermodynamics, Heat Transfer, Fluid Mechanics, CFD

Course Content

The Course is structured into two parts: theory and practical sessions. The theory lectures cover the following topics: Equation of Convection, Finite element analysis, finite volume analysis, Errors and accuracy of numerical models, Turbulence and its models, the commercial codes for computational thermal fluid dynamics. The practical session is dedicated to numerical exercises intended as a moment of verification and clarification of the theoretical knowledge acquired in the lectures. The exercise activities will be carried out in computer lab and practical problems of heat transfer and fluid flow typical of engineering applications will be done. In order to acquire methodological knowledge and application, this part of the course is based on practical exercises developed within Matlab and Comsol Multiphysics environment.

Course Title: PROJECT PART II **L-T-P-C**
Course Code:ME18203 **0-0-4-6**
Pre-requisite: Project Part I

Course Content

After completion of the Project Part I, 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.

Course Title: BEHAVIOR AND DISCIPLINE **L-T-P-C**
Course Code:ZZ18201 **0-0-0-0**

Course Content

This course will provide instruction on educational terminology, assessment and diagnoses, research-based theory and application strategies for classroom management, discipline and social skill development for students with disabilities, especially individuals with behavioral and/or emotional challenges. Students will learn how to identify appropriate prevention and intervention strategies, including functional analysis, applied behavioral analysis, positive behavioral supports and other research-based approaches. In addition, students will learn how to apply these models, using research-supported strategies and practices. Students will learn the legal protections afforded students presenting emotional/behavioral characteristics.

List of Electives
for
B. Tech. in Mechanical Engineering

List of Electives			
Code	**Subjects**	**L-T-P**	**Credit**
ME1*111	Analysis and Design of Manufacturing System	3-0-0	3
ME 1*112	Advanced Material Science	3-0-0	3
ME 1*113	Supply Chain Management	3-0-0	3
ME 1*114	Lean Manufacturing	3-0-0	3
ME 1*115	Advanced Manufacturing Process	3-0-0	3
ME 1*116	Industry 4.0	3-0-0	3
ME1*117	Operations Research	3-0-0	3
ME 1*118	Introduction to Robotics	3-0-0	3
ME1*119	Mechatronics	3-0-0	3
ME1*120	CAM and Automation	3-0-0	3
ME1*121	CAD	3-0-0	3
ME1*122	Theory of Vibrations	3-0-0	3
ME1*123	FEM	3-0-0	3
ME1*124	Composite Materials	3-0-0	3
ME1*125	Fracture Mechanics	3-0-0	3
ME1*126	Multibody System and Dynamics	3-0-0	3
ME1*127	Optimization Methods	3-0-0	3
ME1*128	Power Plant Engineering	3-0-0	3
ME1*129	Renewable Energy Systems	3-0-0	3
ME1*130	Fluid Power Controls	3-0-0	3
ME1*131	Computational Fluid Dynamics	3-0-0	3
ME1*132	Automobile Engineering	3-0-0	3
ME1*133	Gas Dynamics	3-0-0	3
ME1*134	Product Design and Development	3-0-0	3
ME1*135	Design and Development of Smart Materials	3-0-0	3
ME1*136	Heat Exchanger Design	3-0-0	3
ME1*137	Advanced fluid mechanics	3-0-0	3
ME1*138	Engineering Optimization	3-0-0	3
ME1*139	Introduction to additive manufacturing and Rapid prototyping	3-0-0	3
ME1*140	Solar energy and its applications	3-0-0	3
ME1*141	Turbomachinery	3-0-0	3
ME1*142	Advanced Thermodynamics	3-0-0	3
ME1*143	Industrial Tribology	3-0-0	3
Laboratory Elective			
ME1720*	Mechanical Vibration Laboratory	0-0-2	1

Course Title: ANALYSIS AND DESIGN OF MANUFACTURING SYSTEM **L–T–P–C**
Course Code: ME1*111 **3–0–0–3**
Pre-requisite: Industrial Engineering/Production and Operations Management

Course Content

MODULE I (8 Hours)

Introduction to manufacturing system, Types of industry, Components of manufacturing system, Manufacturing strategies, Paradigms of manufacturing, Manufacturing system performance.

MODULE II (12 Hours)

Facility layout design, Procedures in manufacturing system design: from machines to systems, product to process planning, task allocation and sequencing, line balancing; System productivity: machine level performance, reliability vs. productivity, productivity analysis, impact of material handling system on productivity.

MODULE III (10 Hours)

Concept of variability and its effect on manufacturing systems, Cost of manufacturing systems: Investment cost, operations cost, life cycle economics; Just-in-time manufacturing system; System selection criteria: Trade-off analysis, Economic lot sizing and inventory control models.

MODULE IV (6 Hours)

Work system design: anthropometry, human factors, applied ergonomics; Work study: method study, time study, work sampling; Lean manufacturing: Push vs. Pull production system.

Text Books/ References

1. **Hitomi K.,** *Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics*, 2nd Ed., Taylor & Francis, 1996.
2. **Goldberg J. B. and Askin R.G.,** *Design and Analysis of Lean Production Systems*, John Wiley and Sons, 2003.
3. **Barnes R. M**., *Motion and Time Study-Design and Measurement of Work*, 7th Ed. Wiley India Pvt. Ltd., 1980.
4. **Freivalds, A. and Niebel, B. W.,** *Niebel's Methods, Standards, and Work Design*, 13th Ed., McGraw-Hill Publication, 2014.
5. **Miltenburg J.,** *Manufacturing Strategy: How to Formulate and Implement a Winning Plan*, (2ndEd.), Taylor & Francis, 2005.
6. **Ebeling C. E.,** *An Introduction to Reliability and Maintainability Engineering*, Tata McGraw Hill Publication, 2000.

Course Title: ADVANCED MANUFACTURING PROCESSES **L-T-P-C**
Course Code: ME1*115 **3-0-0-3**
Pre-requisite: Casting, Forming and Welding, Theory of Metal Cutting

Course Content

Module I (6 hour) Advanced Casting Processes

Metal mould casting, continuous casting, squeeze casting and semisolid metal casting, vacuum mould casting

MODULE II (6 hours) Advanced Welding Processes

Electron Beam Welding (EBW), Laser Beam Welding (LBW), Ultrasonic Welding (USW), diffusion welding, friction welding

MODULE III (10 hours) Advanced Metal Forming Processes

High Energy Rate Forming (HERF) process, electro-magnetic forming, explosive forming, electro-hydraulic forming, stretch forming

MODULE IV (08 hours) Advanced Machining Processes

Classifications, Mechanical energy-based processes (AWJM and USM); Electrical energy-based processes: EDM, WEDM; Chemical and electro-chemical energy-based processes: CHM and ECM; Thermal energy-based processes: LBM, EBM; working principles, equipment, applications

MODULE V (12 hours): Additive Manufacturing

Rapid prototyping,3-D printing, Laminated Object Manufacturing (LOM), Selective LASER Sintering (SLS), Fused Deposition Modeling (FDM)

Text Books/ References

Text Books:

1. "Manufacturing Engineering & Technology", **Kalpakjian. S.,** Pearson Education Asia.
2. "Principles of modern manufacturing", **M.P. Grover,** John Wiley & Sons
3. "Nontraditional manufacturing processes", **G.F. Benedict,** Marcel Dekker, Inc. New York.

Reference Books:

1. "Advanced machining processes", **Vijay. K. Jain,** Allied Publishers Pvt. Ltd., New Delhi.
2. Materials and Processes in manufacturing" **E. P. DeGarmo, J. GT Black, R. A. Kohser,** Prentice Hall of India, New Delhi
3. "Nonconventional Machining", **P.K. Mishra,** Narosa publishing house, New Delhi.

Course Title: Industry 4.0 **L-T-P-C**
Course code: ME 1*116 **3-0-0-3**

Course Content

MODULE I: Industry 4.0: An Overview of Key Benefits, Technologies, Challenges

Discover Industry 4.0, Industry 4.0 Environment and the different kinds of Internets such as the Internet-of-Things (IoT), Industrial-Internet-of-Things (IIoT), Internet-of-Services (IoS) and IoT in supply chain system, Industrial Processes, Industrial Sensing & Actuation, Industrial Internet Systems, IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication.

MODULE II: Customized Encryption of CAD Models for Cloud-Enabled Collaborative Product Development & A New Approach to Cyber-physical Security in Industry 4.0

Explore the evolution of Industrial Revolutions from - 1st Industrial Revolution by the invention of the 'Spinning Jenny', The 2nd Industrial Revolution powered by the mass production of the famous Henry Ford's Model-T car, assembly lines and electricity, 3rd Industrial Revolution fueled by computerization and automation. Finally, the 4th Industrial Revolution with 'Cyber Physical Systems (CPS)', Advanced Robotics, Artificial Intelligence (AI).

MODULE III: Big Data Security Intelligence for Healthcare Industry 4.0; Decentralized Cyber-Physical Systems

Explore the Impact of Industry 4.0 - Manufacturing Industry, Power Plants, Healthcare Industry such as Precision Medicine and 3D-Printing of organs. Explore the six-layered architecture called '6C Cyber Physical Systems (CPS) Architecture' as an example of the important role of Big Data and Analytics in Industry 4.0, Big Data analysis by ANOVA, correlation, Regression analysis etc.

MODULE IV: Applying and Assessing Direct Digital Manufacturing (DDM), Practical Security Aspects of the IoT and Advanced Manufacturing Environments

Security assessment: Security and Fog Computing in IIoT, Security in IIoT- Application Domains: Factories and Assembly Line, Facility Management, Application Domains: additive manufacturing system and present protocols and recommendations for security best practices for DDM systems, Industry or Plant Safety and Security (Including AR and VR safety applications), The Impact of Industry 4.0 on Governments and the Public Sector, Explore the Impact of Industry 4.0 on the Apparel and the Textile Industry such as Smart Clothing, Customized Clothing etc.

MODULE V: The Challenges of Industry 4.0

Discover the challenges of Industry 4.0 which include IT Security Challenges, Capital Investments, Reliability and Machine-to-Machine (M2M) Communication, Jobs, Skill-set as well as Legal and Compliance Issues.

Course Content

Text Books:

1. **Lane Thames, Dirk Schaefer,** Cybersecurity for Industry 4.0, Analysis for Design and Manufacturing, Springer, Springer Series in Advanced Manufacturing, 2017, DOI 10.1007/978-3-319-50660-9

2. **K. Kumar, D. Zindani, J. Paulo Davim** Industry 4.0: Developments towards the Fourth Industrial Revolution, Springer Briefs in Applied Sciences and Technology (Manufacturing and Surface Engineering), DOI 10.1007/978-981-13-8165-2
3. **Christoph Jan Bartodziej,** The Concept Industry 4.0, An Empirical Analysis of Technologies and Applications in Production Logistics, 2017, DOI 10.1007/978-3-658 16502-4

Reference Books:

1. **Alasdair Gilchrist,** Industry 4.0: The Industrial Internet of Things, 2016, DOI 10.1007/9781-4842-2047-4
2. **Wee, D.; Kelly, R.; Cattel, J.; Breunig, M.** Industry 4.0—How to Navigate Digitization of the Manufacturing Sector; McKinsey& Company: New York, NY, USA, 2015 3. NPTEL Lecture PDF and Video.

Course Title: OPERATIONS RESEARCH **L-T-P-C**
Course Code: ME1*117 **3-0-0-3**
Pre-requisite: Engineering Mathematics, Industrial Engineering

Course Content

MODULE-I (14 Hours)

An overview of operations research modelling approach, Mathematical formulation of linear programming problems, Algebraic solution, simplex algorithm, Artificial starting solution – Big M-method – two phase method, Alternative optimal solutions, Unboundedness, Degeneracy. Duality and Sensitivity: Duality and its concept, dual linear programming, application of elementary sensitivity analysis.

MODULE- II (08 Hours)

Transportation problems: Methods of obtaining optimal solution, degeneracy in transportation problems, solving by linear programming, transhipment problem, Assignment models: Mathematical formulation, methods of solutions. Game Theory – two-person zero-sum games – saddle points, Games with mixed strategies – graphical solutions procedure – solving by linear programming.

MODULE-III (06 Hours)

Network analysis: Development of Network, Time estimates, Time computations. Shortest path flow problem, Successive shortest path flow problem, Maximum flow problem, Minimum cost flow problem.

MODULE-IV (14 Hours)

Queuing Theory: Queuing systems and concepts, classification of queuing situations; Kendall's notation, solution of queuing problems, single channel, single stage, finite and infinite queues with Poisson arrival and exponential service time, applications to industrial problems.

Simulation- introduction, generation of random observations from a probability distribution, simulation of queuing and inventory systems.

Text Books/ 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, 8thEd., Tata McGrawHill, 2005.
3. **Ravindran A., Philips, D., and Solberg, J. J.,** Operations Research: Principles and Practice, 2nded., John Wiley & Sons Inc., 1989.
4. **Vohra N.D.,** Quantitative Techniques in Managements, McGraw Hill Education, 2009.
5. **Hadley, G.,** Linear Programming, Addison Wesley Narosa, Narosa Publishing House, 1987.

Course Title: Introduction to Robotics **L-T-P-C**
Course Code: ME1*118 **3-0-0-3**
Pre-requisite: Kinematics and Dynamics of Machinery, Control Theory and Applications

Course Content

MODULE I (8 Hours) Introduction to Robots and Robotics
Definitions of Robots and Robotics, 3 Hs in Robotics, Motivation behind robotics, A brief history of Robotics, Various components of a robot, Different types of robotic joints, Degrees of freedom of a robotic system, Classification of robots, Workspace Analysis, Resolution, Accuracy and Repeatability, Basics of Boolean Algebra, Applications of Robots, End-effectors/gripper of robots, Robot Teaching, Specification of a robot, Economic Analysis.

MODULE II (12 Hours) Robot Kinematics, Robot Dynamics & Trajectory planning
Position and orientation of 3D objects, Homogeneous Transformation Matrix, Denavit-Hartenberg's Notations, Forward Kinematics, Inverse Kinematics; Polynomial Trajectory, Linear Trajectory with parabolic blends, Jacobian Matrix: Relationship between Cartesian velocity and Joint velocity and Singularity checking; Inverse Dynamics, Lagrange Euler formulation – two approaches**.**

MODULE III (10 Hours) Control scheme, Sensors & Robot Vision
Partitioned Control scheme; Characteristics of a sensor, Classification of sensors, Touch sensor; Position sensors – Potentiometer, LVDT, Optical Encoders, Force/Moment sensors, Range sensor; Proximity sensors – Inductive sensor; Capacitive sensor; Hall Effect sensor; Steps of vision, Image capturing, Sampling – A/D conversion, Frame grabbing, Pre-processing, Thresholding, Edge detection, Boundary descriptors, Identification of objects Passive sensor RCC, Robot drives and actuators.

MODULE IV (10 Hours) Robot Motion Planning, Intelligent Robot & Biped walking
Gross/Free space motion planning, find path problems using Visibility Graph, Voronoi diagram, Cell-Decomposition, Tangent-graph technique, Dynamic Motion Planning Problems, Path–Velocity Decomposition, Accessibility Graph, Relative velocity scheme, Incremental planning, Artificial potential field approach, Reactive control scheme, Behavior-based Robotics; Implement with the help of a wheeled robot; Power consumption, Dynamic balance, Demonstration of a real biped robot, Applications of Industrial robots, Applications of control system in robotics, Pay load capacity, Role of artificial intelligence in Robotics.

Text Books/ References

1. **Robert J Schilling,** Fundamentals of Robotics, Prentice Hall India, 2000
2. **John J Craig,** Introduction to Robotics, Prentice Hall International, 2005
3. **S. R. Deb. S. Deb.** Robotics Technology and Flexible Automation, McGraw-Hill Education (India) Pvt Ltd., 2010
4. **S. K. Saha,,** Introduction to Robotics, McGraw-Hill Education (India) Pvt Ltd., 2014
5. **Ashitava Ghosal,** Robotics: Fundamental Concepts and Analysis, Oxford 2006.

Course Title: THEORY OF VIBRATIONS **L-T-P-C**
Course Code: ME1*122 **3-0-0-3**
Pre-requisites: Kinematics of Machinery/Dynamics of Machinery

Course Content

MODULE I (8 Hours)

Building Vibration Models and Mechanical System Vibration Models: assumptions and approximations - practical case study – deriving the equations of motion.

Single degree of freedom systems: free and forced vibrations –viscous and Coulomb damping - response to harmonic excitation - rotating unbalance - support excitation –transmissibility and vibration isolation.

MODULE II (6 Hours)

Vibration measuring instruments - response to periodic and arbitrary excitation - critical speed of rotors - energy method - Rayleigh's method - equivalent viscous damping –Laplace transform and Fourier transform methods.

MODULE III (12 Hours)

Two-DOF systems: free vibration - matrix formulation - beat phenomenon - forced vibration, principle of vibration absorbers.

Multi-DOF Systems: matrix formulation - stiffness and flexibility influence coefficients - Eigen value problem - normal modes and their properties. Applications of Lagrange's equation in vibration problems.

MODULE IV (9 Hours)

Continuous system Models: equations of motion for transverse vibration of strings - torsional vibration of shafts - axial and beam bending vibrations - forced vibration of continuous systems using modal Superposition. Approximation methods: Rayleigh-Ritz and Galerkin based solutions.

MODULE V (4 Hours)

Vibration model analysis using FEM: To determine the natural mode shapes and frequencies of an object or structure during free vibration, forced vibration in Single degree of freedom systems and two degree of freedom systems.

Text Books/ References

Text Books:

1. **S. S. Rao,** 2003, Mechanical Vibrations, 4th Edition, and Pearson India: New Delhi.

2. W. T. Thomson, M. D. Dahleh and C. Padmanabhan, 2008, Theory of Vibration with Applications, Pearson Education India: New Delhi.

3. L. Meirovitch, 2001, Elements of Vibration Analysis, Tata McGraw-Hill: New Delhi.

Reference Books:

1. **B. Ramachandran, E. B. Magrab,** 2009, Fundamentals of Vibrations, Cengage Engineering: New Delhi.

2. V. Ramamurti, 2012**,** Mechanical Vibration Practice and Noise Control, Narosa: New Delhi.

3. S. J. P. Den Hartog, Mechanical Vibrations. McGraw-Hill, 1956.

Course Title: FINITE ELEMENT METHODS **L-T-P-C**
Course Code: ME1*123 **3-0-0-3**
Pre-requisites: NIL

Course Content

MODULE I (10 Hours)

Introduction to Finite Element Method (FEM); Philosophy of FEM, Nodes, Element and Shape Functions; Polynomials as Shape Functions, Weighted Residuals, Element and Assembly level equations; Types of Errors in FEM, Overall FEM process, Convergence; Strengths of FE Method, Continuity conditions at Interfaces; Key concepts and terminologies; Weighted integral statements; Integration by parts –Review; Gradient and Divergence Theorems-Part I; Gradient and Divergence Theorems Part-II; Functionals.

MODULE II (8 Hours)

Variational Operator; Weak Formulation & Weighted Integral: Principle of minimum potential energy; Variational Methods: Rayleigh Ritz Method; Method of Weighted Residuals; Different types of Weighted Residual Methods; FEM formulation for 2nd order BVP; Element Level Equations. 2nd Order Boundary Value Problem; Assembly of element equations, and implementation of boundary conditions; Assembly process and the connectivity matrix; Radially Symmetric Problems.

MODULE III (12 Hours)

One dimensional heat transfer; 1D-Heat conduction with convective effects: examples; Euler-Bernoulli beam; Interpolation functions for Euler-Bernoulli beam; Finite element equations for Euler-Bernoulli beam; Assembly equations for Euler-Bernoulli beam; Boundary conditions for Euler-Bernoulli beam; Review of bending of beams, higher order continuity (C^0 and C^1 Continuity), interpolation for beam elements and formulation of FE characteristics, Plane Trusses: local and global coordinate system, element stiffness matrix, stress calculations, temperature effects.

MODULE IV (10 Hours)

Two dimensional and three dimensional Problems; two dimensional problems using constant strain triangle element: Isoparametric representation, potential energy approach, element stiffness matrix, force terms, Galerkin's approach, stress calculations, temperature effects; formulation for 2-D and 3-D heat conduction problems with convective boundaries; mesh preparation; tetrahedral and hexahedral elements; Introduction to thermo-elastic contact problems; Finite element applications in potential flows; Formulation based on Potential function and stream function; design case studies.

Text Books/ References

1. **C.S. Krishnamurthy**, "Finite Element Analysis", Tata McGraw Hill, New Delhi.
2. **TripathiR** , "Introduction to Finite Element Engineering", Prentice Hall of India, Pvt.Ltd New Delhi.
3. **Klaus, Jurgen Bathe,** "Finite Element Procedures in Engineering Analysis", Prentice Hall of India Pvt. Ltd. New Delhi.
4. **Reddy, J.N.,** An Introduction to the Finite Element Method, Tata McGraw-Hill.
5. **Zienkiewicz, O.C.,** The Finite Element Method, Tata McGraw-Hill Edition.

Course Title: COMPUTATIONAL FLUID DYNAMICS **L-T-P-C**
Course Code: ME1*131 **3-0-0-3**
Pre-requisite: Fluid Mechanics, Heat Transfer and Numerical Analysis Techniques

Course Content

MODULE I (10 Hours)

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering: the impact of Computational Fluid Dynamics on aerospace, automobile and engine applications, Industrial manufacturing applications, environmental engineering applications, biomedical science and engineering applications. Governing equations of Computational Fluid Dynamics: Models of the flow, the substantial derivative, divergence of velocity, continuity equation, momentum equation, energy equation, Physical boundary conditions.

MODULE II (12 Hours)

Classification of Partial differential equations: General method of determining the classification of partial differential equations, The impact of different equation on Computational Fluid Dynamics: Hyperbolic equations, Parabolic equations and Elliptic equations. Numerical solution of elliptical equations-Linear system of algebraic equations, Numerical solution of parabolic equations -Stability analysis, Numerical solution of hyperbolic equations - Burgers equation.

MODULE III (12 Hours)

Basic aspects of Discretization: Introduction to finite differences and finite volume formulations, Difference equations, Explicit, implicit and Crank-Nicolson schemes, Solution of the Algebraic Equations, Consistency, stability and convergence of computational methods, validation of computational solution. Incompressible Navier-Stokes equations and algorithms -basics of grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation. Discretization of Navier Stokes Equations: Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm. Finite Volume Method for Unstructured Grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements.

MODULE IV (8 Hours)

The basic structure of a CFD code: Pre-processor, Solver and Postprocessor, User-definedsubroutines, Solution to some basic problems in heat transfer and fluid flow. Case study: Application of Computational Fluid Dynamics simulation: Indoor Airflow distribution, Gas-particle flow in a 900 bends, Heat exchanger, Air/particle flow in the human nasal cavity, Subsonic and supersonic flows over a wing and Supersonic flow over a flat plate.

Text Books/ References

Text Books:

1. Computational Fluid Mechanics and Heat Transfer**, Tannehill, J.E., Anderson, D.A., andPletcher, R.H.,** 2nd Ed., Taylor & Francis, 1997.

2. Computational Fluid Dynamics for Engineers, Engineering Education Systems, Hoffmann, **K.A. and Chiang, S.T**., 2000.

References:

1. Computational Fluid Dynamics –The basics with applications, **Andeson J.D.,** McGrawHill, 1995.
2. Numerical Heat Transfer & Fluid Flow, Patankar, **S.V., Hemisphere**, 1980.
3. An Introduction to Computational Fluid Dynamics –The finite volume method, Versteeg, **H.K. and Malalasekera, W.,** Longman Scientific & Technical, 1995.

Course Title: Automobile Engineering **L-T-P-C**
Course Code: ME1*132 **3-0-0-3**

Course Content

MODULE I (8 Hours)

Classification of Automobiles, Components of Automobiles, Automobile engine systems, Review of IC Engines: Classification for automotive use, 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, Engine Performance, Ignition systems – conventional - modern, Fuel injection systems - conventional - nonconventional engines, Lubrication - purpose of lubricating systems - grading of lubricating oils - Lubrication systems.

MODULE II (8 Hours)

Vehicle body terminology, Chassis and suspension - chassis lay out, 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.

MODULE III (8 Hours)

Brakes - mechanical and hydraulic brakes - vacuum - servo and air brakes - components of braking systems and their functions - constructional details, ABS. Steering mechanisms - steering geometry - steering gears - worm and wheel gears - power assisted steering. Suspension, independent suspension - Road springs - Shock absorbers - torsion bars, Air suspension systems.

MODULE IV (8 Hours)

Effect of frictional resistance on vehicle, tractive effect and force calculation, Wheels - tyres and tubes, starting mechanism, starter drives - over running clutch drive. Electrical equipments - charging circuit – regulators.

Air pollution and control - Pollution rating - Catalytic converters, Emission Standards: Euro I, II, III and IV norms - Bharat Stage II, III, IV norms - Motor Vehicle Act.

MODULE V (8 Hours)

Electric and Hybrid Vehicles, electric propulsion systems: DC motor drives, induction motor drives, drives and control circuits, hybrid electric drive train design, energy storages: Electric batteries - types - thermal effects on batteries, Supercapacitors, fuel cell powered vehicles. Case study: Contemporary Hybrid electric technology.

Text Books/ References

1. **Joseph Heitner,** Automotive mechanics Principles and Practices, 2nd ed., D. Van Nostrand Company, 2006.
2. **Newton. K and Steeds.W,** The Motor Vehicle, 13th ed. The English Language Book Society and Newnes Butterworth, London, 2004.
3. **William H Crouse and Donald L Anglin**, Automotive Mechanics, 10th ed., Pearson Higher Education,2004.
4. **William H Crouse and Donald L Anglin,** Automotive engine, 8th ed., McGraw-Hill, 1995.
5. **Ehsani M, Gao Y, Gay S.E and Emadi A,** Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design. CRC Press, 2004.
6. **Hussein I, Electric and Hybrid Vehicles:** Design. Fundamentals, Theory and Design. CRC Press, 2003.
7. **Sajith V, and Thomas S,** Internal Combustion Engines, 1st ed. Oxford University Press, 2017.

Course Title: COMPOSITE MATERIALS **L-T-P-C**
Course Code: ME1*135 **3-0-0-3**
Pre-requisite: Material Science & Metallurgy

Course Content

MODULE I (10 Hours) Introduction:

Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential.

MODULE II (12 Hours) Various types of composites:

Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites.

MODULE III (09 Hours) Fabrication methods:

Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pultrusion, pre-peg layer, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films.

MODULE IV (11 Hours) Testing of Composites:

Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc. Generalized Hill's Criterion for

Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure.

Text Books/ References

1. Materials characterization, Vol. 10, ASM hand book
2. Mechanical Metallurgy by **G. Dieter** Mc-Graw Hill
3. Thermal Analysis of Materials by **R.F. Speyer, Marcel Decker**
4. Engineering Materials: Polymers, Ceramics and Composites **A.K Bhargava** Prentice Hall of India.

Course Title: DESIGN OF HEAT EXCHANGERS **L-T-P-C**
Course Code: ME1*136 **3-0-0-3**
Pre-requisite: Heat Transfer, Thermodynamics

Course Content

MODULE I (10 Hours)

Introduction, classification, applications and selection criteria of heat exchangers, Overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel and counter flow heat exchangers, e-NTU method for heat exchanger analysis, fouling, cleanliness factor, techniques to control fouling, rating and sizing problems, design methodology.

MODULE II (15 Hours)

Inline and staggered arrangement of Tubular Heat Exchangers, Heat Transfer Co-efficient, Double Pipe, Thermal and hydraulic design of inner tube and annulus, Pressure drop.
Basic components of Shell & tube heat exchangers, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method.
Compact Heat Exchangers types, Plate heat exchangers, Enhancement of Heat Transfer using Extended Surfaces, Performance evaluation of augmented surfaces, Analysis of fin plates of tube fin heat exchanger and Plate fin heat exchanger, heat transfer and pressure drop calculations.

MODULE III (9 Hours)

Evaporator, Condenser, Heat pipes and Heat pipe heat exchangers, Micro Heat Exchangers, Micro Channels, Design of Fixed Bed Regenerators, Air washer, Cooling towers.

MODULE IV (6 Hours)

Heat exchanger network, pinch analysis, Heat Exchanger standards and Testing, Use of commercial software packages for design and analysis, Optimization of Heat exchangers.

Text Books/ References

Text Books:

1. **T.Taborek, G.F.Hewitt and N.Afgan,** "Heat Exchangers, Theory and Practice", McGrawHill Book Co.,1980.
2. **SadikKakac and Hongtan Liu,** "Heat Exchangers Selection", Rating and Thermal Design, CRC Press, 2002.
3. **Shah,R. K., Dušan P. Sekulić,** "Fundamentals of heat exchanger design", John Wiley & Sons, 2003.

References:

1. **Robert W. Serth,** "Process heat transfer principles and applications", Academic press, Elesevier, 2007.
2. **Sarit Kumar Das,** "Process heat transfer", Alpha Science International, 2005.
3. **Yonous A. Cengel,** "Heat transfer: A Practical Approach", McGraw Hill, 2002.
4. **John E. Hesselgreaves**, "Compact heat exchangers: selection, design, and operation", Elsevier science Ltd, 2001.
5. **Kuppan. T.,** "Heat exchanger design hand book", New York: Marcel Dekker, 2000. Eric M. Smith, "Advances in thermal design of heat exchangers: a numerical approach: direct-sizing, step-wise rating, and transients", John Wiley & Sons, 1999.
6. **W. M. Kays, A. L. London,** "Compact Heat Exchangers", Krieger Pub Co, 1998.

Course Title: ADVANCED FLUID MECHANICS **L-T-P-C**
Course Code: ME1*137 **3-0-0-3**
Pre-requisite: Fluid Mechanics

Course Content

MODULE I (12 Hours)

Basic Concepts and Fundamentals - Definition and properties of Fluids, Fluid as continuum, Langragian and Eulerian description, Velocity and stress field, Stress tensor,Fluid statics, Fluid Kinematics, Governing Equations of Fluid Motion-Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier Stokes equations, Euler's equation, Bernoulli's Equation, Exact solutions of Navier-Stokes Equations: Couette flows, Poiseuille flows, fully developed flows in non-circular cross sections, Unsteady flows, Creeping flows.

MODULE II (10 Hours)

Potential Flows-Revisit of fluid kinematics, Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet ,Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag, Laminar Boundary Layers-Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flow into a duct.

MODULE III (8 Hours)

Elements of Stability Theory-Concept of small-disturbance stability, Orr-Sommerfield equation, Inviscid stability theory, Boundary layer stability, Thermal instability, Transition to turbulence, Fluctuations and time averaging, General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis, Turbulence modeling, Free turbulent flows.

MODULE IV (10 Hours)

Compressible Flows: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, PrandtlMeyer expansion waves, Quasione dimensional flows, Compressible viscous flows, Compressible boundary layers, Introduction to Computational Fluid Dynamics (CFD)-Boundary conditions, Basic discretization – Finite difference method, Finite volume method and Finite element method.

Text Books/ References

1. **Batchelor G.K,An** Introduction to Fluid Dynamics, Cambridge University Press, 1983.
2. **Fox W. Robert, McDonald T.Alan,** Introduction to Fluid Mechanics, Fourth Edition, John Wiley & Sons, 1995.
3. **Frank M. White,** Fluid Mechanics, Tata McGraw-Hill, Singapore, Sixth Edition, 2008.
4. **Frank M. White,**Viscous Fluid Flow, Third Edition, McGraw-Hill Series of Mechanical Engineering, 2006.
5. **John D.Anderson Jr, Modern** Compressible Flow with Historical Perspective, McGrawHill, 1990.
6. **John D.Anderson Jr.,** Fundamentals of Aerodynamics, Mc.Graw Hill, 2005.
7. **John D. Anderson Jr.,** Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Series of Mechanical Engineering, 1995.
8. **Milton Van Dyke,**An Album of Fluid Motion, The Parabolic press, Stanford University, 1982
9. **Muralidhar K. and Biswas G.,** Advanced Engineering Fluid Mechanics, Second Edition, Narosa, 2005.
10. **Panton R.L.,** Incompressible Flow, John Wiley and Sons, 2005.
11. **Pijush K.Kundu and Ira M. Cohen**, Fluid Mechanics, Fourth Edition, Academic Press (ELSEVIER), 2008.
12. **Schlichting H.,** Boundary Layer Theory, Springer Verlag, 2000.
13. **Tennekes H. and Lumley J.L**. A First Course in Turbulence, The MIT press, 1972.

Course Title: ENGINEERING OPTIMIZATION **L-T-P-C**
Course Code: ME1*138 **3-0-0-3**
Pre-requisite: Theory of Metal Cutting/ KOM/ DOM

Course Content

MODULE I (04 Hours)

Introduction General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints - Classification of optimization problems.

MODULE II (14 Hours)

Optimization techniques Single variable and multivariable optimization, Techniques of unconstrained minimization - Golden Section -Random, pattern and gradient search methods -Interpolation methods; Optimization with equality and inequality constraints - Direct methods - Indirect methods using penalty functions Lagrange multipliers; Geometric programming and stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques.

MODULE III (10 Hours)

Material handling and facilities planning, Design of Jigs and Fixtures, Blanking and Piercing die design- Strip layout – Short-run tooling for Piercing, Tool Design for CNC machine tools**,** Automatic tool changers and tool positioners – Tool pre-setting– General explanation of the Brown and Sharp machine.

MODULE IV (14 Hours)

Engineering applications Structural applications - Design of simple truss members. Design application - design of simple axial, transverse loaded members for minimum cost, maximum weight, - Design of shafts and torsionally loaded members -Design of springs, Dynamic Applications - Optimum design of single, two-degree freedom system, vibration absorbers. Application in Mechanism - Optimum design of simple linkage mechanism.

Text Books/ References

Text Books:

1. **Jasbir. Arora**, Introduction to optimum Design, Elsevier
2. **Singeresu S. Rao,** "Engineering Optimization - Theory and Practice" New Age Intl. Ltd., Publishers, 2000. References:
3. **Johnson Ray, C.,** "Optimum design of mechanical elements", Wiley, John & Sons, 1981.
4. **Goldberg, D.E.,** "Genetic algorithms in search, optimization and machine", Barnen, Addison-Wesley, New York, 1989.
5. **Kalyanamoy Deb,** "Optimization for Engineering design algorithms and Examples", PHI India,199

Reference Books:

1. Cyrll Donaldson, **George H.LeCain, V.C. Goold,** "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2000.
2. **E.G.Hoffman**," Jig and Fixture Design", Thomson Asia Pvt Ltd, Singapore, 2004 .
3. **Venkataraman K.,** "Design of Jigs, Fixtures and Presstools", TMH, 2005
4. **Haslehurst M.,** "Manufacturing Technology", The ELBS, 1978.

Course Title: ADDITIVE MANUFACTURING AND RAPID PROTOTYPING **L-T-P-C**
Course Code: ME1*139 **3-0-0-3**
Pre-requisite: Control Theory and Application, Basic Manufacturing Process

Course Content

MODULE I (6 Hours)

Introduction to Additive Manufacturing (AM), General overview Introduction to reverse engineering Traditional manufacturing viz. AM, Computer aided design (CAD) and manufacturing (CAM) and AM Different AM processes and relevant process physics AM process chain. Application level: Direct processes - Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing.

MODULE II (8 Hours)

Materials science for AM Discussion on different materials used, Use of multiple materials, multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, Structure property relationship, Grain structure and microstructure.

MODULE III (12 Hours)

AM technologies, Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting involvement). Printing processes (droplet-based 3D) Solid-based AM processes - extrusion based fused deposition modelling object Stereolithography Micro- and Nano-additive.

MODULE IV (14 Hours)

Mathematical models for AM, Transport phenomena models, temperature, fluid flow and composition, buoyancy driven tension, driven free surface flow pool. Case studies:
Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport, Simulations (choice of parameter, Model validation for different processes) Process selection, planning, control for AM, Selection of AM technologies using decision methods, Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects, transformation.

Text Books/ References

Text Books:

1. **Ian Gibson, David W. Rosen and Brent Stucker,** Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
2. **C.K. Chua, K.F. Leong and C.S. Lim,** Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.

References:

1. **Andreas Gebhardt,** Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
2. **J.D. Majumdar and I. Manna,** Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.

3. **L. Lu, J. Fuh and Y. S. Wong,** Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
4. **Zhiqiang Fan and Frank Liou,** Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, ln Tech, 2012.

Course Title: SOLAR ENERGY AND ITS APPLICATIONS **L-T-P-C**
Course Code: ME1*140 **3-0-0-3**
Pre-requisite: Heat transfer

Course Content

MODULE I (6 Hours)

The energy crisis: causes and options, renewable and non-renewable forms of energy and their characteristics, solar energy option –availability and land area requirements. Solar constant, Extraterrestrial and Terrestrial radiation, Direct and diffuse radiations, measurement of solar radiation, Sun-Earth geometry.

MODULE II (8 hours)

Optical Properties: Effective transmittance absorptance product; daily and monthly average daily transmittance-absorptance product, Liquid flat-plate collectors-design and performance parameters, solar air heaters, concentrating collectors and energy storage.

MODULE III (14 hours)

Solar thermal power generation-low, medium and high temperature applications: solar cooling, drying and desalination, solar air and water heating, air conditioning and refrigeration, cold storages. Computational and analytical approaches-Component model and Simulations.

MODULE IV (10 hours)

Solar photovoltaic power generation-monocrystalline, polycrystalline and amorphous cells, Fabrication and performance of SPV modules. Impact of solar energy on biomass, wind, wave and ocean thermal energy conversion technologies. Economic considerations.

Text Books/ References

1. Solar Energy–Fundaments, Design, Modelling & Applications' **by G.N. Tiwari** 2002, Narosa Publishing House, New Delhi, India.
2. Solar Energy Engineering' by **S. Kalogirou**, Academic Press.
3. Heat & Mass transfer' **by Y.A. Cengel,** Mcgraw Hill.
4. Solar Engineering of Thermal Processes' by **J.A. Duffie and W.A. Beckman 1991**. John Wiley and Sons Inc., New York.
5. Solar Energy-Principles of Thermal Collection and Storage'by **Sukhatme**, TataMcgraw Hill
6. Solar Energy-Fundamentals and Applications' by **Garg and Prakash**, Tata Mcgraw Hill.
7. Advanced Renewable Energy Sources' by **G.N. Tiwari and R.K. Mishra** 2012, RSC Publishing, Cambridge, U.K.

Course Title: TURBOMACHINERY **L-T-P-C**
Course Code: ME1*141 **3-0-0-3**
Pre-requisite: Fluid Mechanics, Fluid Machinery, Thermodynamics

Course Content

MODULE I (8 Hours)

Introduction: Introduction to Turbomachines. Classification of Turbomachines-turbine/compressor work, Nozzle/diffuser work. Fluid equations - continuity, Euler's, Bernoulli's equation and its applications. Expansion and compression processes, Reheat Factor, Preheat Factor, Euler's Equation of Energy Transfer, Components of energy transfer; Introduction to two-dimensional cascade theory.

MODULE II (12 Hours):

Compressors: Centrifugal compressors; Flow through Centrifugal compressors. Stage velocity triangles, specific work, forward, radial and backward swept vanes. Enthalpy entropy diagram, degree of reaction, slip factor, efficiency. Vane less and vaned diffuser systems, volute casing. Surge and stall in compressors

Axial flow compressors; Cascade analysis, vortex theory, work required, polytropic efficiency, pressure rise, degree of reaction; Simple design calculations; Surging and stalling of compressors; Compressor performance and characteristic curves.

MODULE III (12 Hours)

Turbines: Axial, Radial and Mixed Flow Turbines; Non-dimensional performance parameters; Specific speed, Degree of Reaction, Velocity triangles for different values of degree of reaction, utilization factor, Relation between degree of reaction and Utilization factor, influence of relative circulation, thickness of vanes and number of vanes on velocity triangles, Steam and gas turbines; Steam flow through nozzles, critical pressure ratio, and choking of nozzles; Throat and exit areas for optimum discharge; Compounding of steam turbines; Efficiency and Performance. Axial flow gas turbines; Axial turbine stages, stage velocity triangles, Turbine characteristics and performance. Losses in turbo machines.

MODULE IV (8 Hours)

Fans and Blowers: Construction and classification Power required, pressure rise, efficiency calculations; Applications in boilers, cooling towers and other industrial applications. Performance and characteristics of axial fans, Application of fans for air circulation and ventilation. Stage pressure rise and work done.

Text Books/ References

1. Principals of Turbo machines, **D. G. Shepherd**, The Macmillan Company (1964).
2. Fluid Mechanics & Thermodynamics of Turbo machines, **S. L. Dixon,** Elsevier (2005).
3. Principles of Turbomachinery, **R.K.Turton,** E & F N Spon Publishers, London & New York.
4. Text Book of Turbo machines, **M. S. Govindegouda and A. M. Nagaraj,** M. M. Publications, 4thEd, 2008.
5. Turbo Machineries" **B. K. Venkanna,** PHI.

Course Title: ADVANCED THERMODYNAMICS **L-T-P-C**
Course Code: ME1*142 **3-0-0-3**
Pre-requisite: Thermodynamics

Course Content

MODULE I (10 Hours)

Review of fundamentals, Entropy, Carnot theory, Entropy of the ideal gas, T-s diagram, Entropy and reversibility, Entropy and irreversibility, Irreversible part of the second law, Heat and entropy in irreversible processes, Entropy and non-equilibrium states, Principle of increase of entropy, Application of the entropy principle, Entropy and disorder.

MODULE II (10 Hours)

Exergy, Exergy analysis of thermodynamic systems, Applications of exergy analysis of thermodynamic operations and cycles, Thermodynamic potentials–postulates, Thermodynamic property relations – Maxwell relations, Joule-Thomson coefficient, Claperon equation, Thermodynamic properties of real gases – ideal gas properties - Multi-component mixtures.

MODULE III (10 Hours)

Reversible processes, Maximum work theorem, Stability and phase transitions – stability criteria, first order phase transition, single and multi-component systems, Gibbs phase rule, phase diagram of binary systems; Fugacity and fugacity coefficient, properties of real gas mixtures, fugacity of liquid, solid and component in a mixture.

MODULE IV (12 Hours)

Introduction to chemical thermodynamics and flame temperatures, Heat of reaction and formation, Free Energy and equilibrium constants, Flame temperatures and equilibrium composition.

Text Books/ References

1. **Y.A. Cengal and M.A. Boles**, Thermodynamics: An Engineering Approach, McGraw Hill (Fifth edition).
2. **Nag, P.K., Engineering** Thermodynamics, Fifth Edition, McGraw Hill Education (India) Private Limited.
3. **Callen, H.B.,** Thermodynamics and an Introduction to Thermostatics, Second Edition, John Wiley & Sons, 1985.
4. **Rao, Y.V.C.,** Postulational and Statistical Thermodynamics, Allied Publishers, 1994.
5. **Zemansky, M.W., Abbot, M.M. and Van Ness, H.C.,** Basic Engineering Thermodynamics, McGraw-Hill, 1987
6. **Saad, M.A**., Thermodynamics for Engineers, Prentice Hall of India, 1987.

Course Title: INDUSTRIAL TRIBOLOGY **L-T-P-C**
Course Code: ME1*143 **3-0-0-3**
Pre-requisite: Fluid Mechanics and Machinery, Applied Mechanics of Solids

Course Content

MODULE: I (8 Hours)

1. Introduction: (8 Hours)

Tribology in design, tribology in industry Viscosity, flow of fluids, viscosity and its variation absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers, Tribological considerations Nature of surfaces and their contact; Physic mechanical properties of surface layer, Geometrical properties of surfaces, methods of studying surfaces; Study of contact of smoothly and rough surfaces.

MODULE: II (6 Hours)

2. Friction and wear: (6 Hours)

Role of friction and laws of static friction, causes of friction, theories of friction, Laws of rolling friction; friction of metals and non-metals; friction measurements. Definition of wear, mechanism of wear, types and measurement of wear, friction affecting wear, Theories of wear; Wear of metals and non-metals.

MODULE: III (18 Hours)

3.1 Hydrostatic lubrication: (6 Hours)

Principle of hydrostatic lubrication, General requirements of bearing materials, types of bearing materials., Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, Hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing, optimum design of hydrostatic step bearing.

3.2 Hydrodynamic theory of lubrication: (6 Hours)

Principle of hydrodynamic lubrication, Various theories of lubrication, Petroff's equation, Reynold's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl, anti –friction bearing, hydrodynamic thrust bearing.

3.3 Air/gas lubricated bearing: (6 Hours)

Advantages and disadvantages application to Hydrodynamic journal bearings, hydrodynamic thrust bearings. Hydrostatic thrust bearings. Hydrostatic bearing Analysis including compressibility effect.

MODULE: IV (10 Hours)

4.1 Lubrication and lubricants: (6 Hours)

Introduction, dry friction; Boundary lubrication; classic hydrodynamics, hydrostatic and elasto hydrodynamic lubrication, Functions of lubricants, Types of lubricants and their industrial uses; SAE classification, recycling, disposal of oils, properties of liquid and grease lubricants; lubricant additives, general properties and selection.

4.2 Special Topics: (4 Hours)

Selection of bearing and lubricant; bearing maintenance, diagnostic maintenance of Tribological components and considerations in IC engines and automobile parts, roller chains and wire rope, lubrication systems; Filters and filtration Processes.

Text Books/ References

Text Books:

1. Fundamentals of Tribology, **Basu, SenGupta and Ahuja**/PHI
2. Tribology in Industry, **Sushil Kumar Srivatsava**, S. Chand &Co.
3. Tribology **H.G.Phakatkar and R.R.Ghorpade** Nirali Publications
4. Tribology **– B.C. Majumdar,** McGraw Hill Co Ltd.
5. Standard Hand Book of Lubrication Engg., **O'Conner and Royle**, McGraw Hills C
6. Introduction to Tribology**, Halling,** Wykeham Publications Ltd.
7. Lubrication, **Raymono O. Gunther**; Bailey Bros & Swinfan Ltd.
8. Bearing Systems, Principles and Practice, **PT Barwll**
9. Tribology Hand Book, **Michel Ncole**

Reference Books

1. Principles of Tribology by **Halling j**., McMillan Press Ltd.
2. Friction and Wear of Engineering Materials by,**I.M. Hutchings, Edwar Arnold,** London, 1992.
3. Friction and Lubrication **E.P. Bowden and Tabor.,** Heinemann Educational Books Ltd.,1974.

Elective Laboratory

Course Title: MECHANICAL VIBRATION LABORATORY **L-T-P-C**
Course Code: ME17203 **0- 0- 2-1**
Pre-requisite: Kinematics of Machinery/Dynamics of Machinery

Course Content

Course Content: Analysis of the free vibration of single-degree of freedom linear systems, and damped torsional vibrations, Determinations of the oscillation period depending on torsion wire length, diameter and rotating shaft, Case study on the torsional vibration of a geared system, Torsional vibration with harmonic excitation, Critical speed of an elastic shaft having a single disc and multiple disc with damping, Whirling of rotating elastic shafts, Uses of pick-ups, oscillator and amplifiers for measurement of vibration and acceleration.
To determine the resonance frequency of damping forced vibration from the amplitude vs. excitation frequency and the phase angle vs. excitation curve using software like LabVIEW and their data acquisition system. Performance of experiment to find out damping ratio for the system via the phase angle vs. excitation frequency curve using software and data acquisition system.

Text Books/ References

Text Books:

1. **W. T. Thomson, M. D. Dahleh and C. Padmanabhan,** 2008, Theory of Vibration with Applications, Pearson Education India: New Delhi.
2. **L. Meirovitch, 2001,** Elements of Vibration Analysis, Tata McGraw-Hill: New Delhi.
3. **S. S. Rao,** 2003, Mechanical Vibrations, 4th Edition, and Pearson India: New Delhi.

Reference Books:

1. **B. Ramachandran, E. B. Magrab,** 2009, Fundamentals of Vibrations, Cengage Engineering: New Delhi.
2. **V. Ramamurti,** 2012, Mechanical Vibration Practice and Noise Control, Narosa: New Delhi.
3. **J. P. Den Hartog,** Mechanical Vibrations. McGraw-Hill, 1956.