NATIONAL INSTITUTE OF TECHNOLOGY SIKKIM

DEPARTMENT OF MECHANICAL ENGINEERING

Final course structure from 3rd Semester to 8th Semester (2014, 2015 & 2016 batch)

Semester 3

No	Code	Subject	L	T	P	C	Category
1	MA2001	Mathematics III	3	1	0	3	BS
2	EE2009	Electrical Measurements and Machines	3	0	0	3	PT
3	ME2001	Mechanics of Fluids	3	0	0	3	PT
4	ME2002	Elements of Solid Mechanics	3	0	0	3	PT
5	ME2003	Engineering Mechanics – Dynamics	3	0	0	3	PT
6	ME2101	Materials Science and Metallurgy	3	0	0	3	PT
7	ME2091	Machine Drawing	0	0	3	2	PT
8	EE2094	Electrical Measurements and Machines Laboratory	0	0	3	2	PT
		Total	18	1	6	22	

Semester 4

No	Code	Subject	L	T	P	C	Category
1	MA2002	Mathematics IV	3	1	0	3	BS
2	ME2011	Fluid Machinery	3	0	0	3	PT
3	ME2012	Applied Mechanics of Solids	3	0	0	3	PT
4	ME2013	Mechanics of Machinery	3	0	0	3	PT
5	ME2014	Thermodynamics	3	0	0	3	PT
6	ME3003	Environmental Studies for Mechanical Engineers	3	0	0	3*	OT
7	ME2092	Fluid Mechanics & Fluid Machinery Laboratory	0	0	3	2	PT
8	CE2095	Strength of Materials Laboratory	0	0	3	2	PT
		Total	18	1	6	19+3*	

Semester 5

No	Code	Subject	L	T	P	C	Category
1	ME3001	Dynamics of Machinery	3	0	0	3	PT
2	ME3002	Principles of Heat Transfer	3	0	0	3	PT
3	ME3101	Management of Production Systems	3	0	0	3	PT
4	ME3102	Manufacturing Science	3	0	0	3	PT
5	ME3011	Gas Dynamics	3	0	0	3	PT
6	ME4101	Operations Research	3	0	0	3	HL
7	ME3091	Heat Transfer Laboratory	0	0	3	2	PT
8	ME3191	Production Engineering Laboratory I	0	0	3	2	PT
		Total	18	0	6	22	

Semester 6

No	Code	Subject	L	T	P	C	Category
1	ME3111	Machining Science and Machine Tools	4	0	0	4	PT
2	ME3112	Metrology and Instrumentation	3	0	0	3	PT
3		Elective I	3	0	0	3	PT
4	ME3012	Thermal Engineering I	3	0	0	3	PT
5	ME4001	Machine Design I	3	0	0	3	PT
6	ME3192	Metrology and Instrumentation Laboratory	0	0	3	2	PT
7	ME3193	Production Engineering Laboratory II	0	0	3	2	PT
		Total	16	0	6	20	

Semester 7

No	Code	Subject	L	T	P	C	Category
1	ME4002	Thermal Engineering II	3	0	0	3	PT
2		Elective II	3	0	0	3	PT
3	ME4011	Machine Design II	3	0	0	3	PT
4	MS4004	Industrial Economics	3	0	0	3	PT
5	ME4098	Project	0	0	3	3	PT
6	ME4091	Heat Engine Laboratory	0	0	3	2	PT
7	ME4191	CAD/CAM Laboratory	0	0	3	2	PT
		Total	12	0	9	19	

Semester 8

No	Code	Subject	L	T	P	C	Category
1		Elective III	3	0	0	3	PT
2	ME2111	Essential of Management	3	0	0	3	PT
3		Elective IV	3	0	0	3	PT
4		Elective V	3	0	0	3	PT
5	ME4099	Project	0	0	5	5	PT
6	ME4097	Seminar	0	0	3	1	PT
		Total	12	0	8	18	

List of Electives

No.	Code	Subject
1	ME3021	Introduction to Finite Element Methods
2	ME3022	Experimental Stress Analysis
3	ME3023	Theory of Plasticity
4	ME3024	Control Systems Engineering
5	ME3025	Nonlinear Dynamics and Chaos
6	ME3026	Engineering Fracture Mechanics
7	ME3027	Fluid Power Controls
8	ME3028	Advanced Thermodynamics
9	ME3029	Computational Methods in Engineering
10	ME3121	Powder Metallurgy
11	ME3122	Introduction to Marketing
12	ME3123	Design and Analysis of Management Information Systems
13	ME3124	Work Design and Measurement
14	ME3125	Cost Analysis and Control
15	ME3126	Supply Chain Management
16	ME3127	Management of Organisational Behaviour
17	ME3128	Production Planning and Control
18	ME3129	Management of Human Resources
19	ME3130	Quality Planning and Analysis
20	ME4021	Industrial Tribology
21	ME4022	Vehicle Dynamics
22	ME4023	Introduction to Robotics
23	ME4024	Design for Manufacturability
24	ME4025	Mechatronics
25	ME4026	Unconventional Energy Systems
26	ME4027	Computational Fluid Dynamics
27	ME4028	Aerodynamics
28	ME4029	Heating, Ventilation and Air Conditioning
29	ME4030	Fundamentals of Combustion
30	ME4031	Refrigerating and Air Conditioning Systems
31	ME4032	Automobile Engineering
32	ME4033	Introduction to Computer Graphics
33	ME4034	Experimental Methods in Fluid Flow and Heat Transfer
34	ME4122	Mechanical Behaviour and Testing of Materials
35	ME4123	Technology Management
36	ME4125	Competitive Manufacturing Management
37	ME4126	Engineering Optimization
38	ME4127	Accounting and Finance for Engineers
39	ME4128	Simulation Modelling and Analysis
40	ME4129	Modelling of Manufacturing Systems
41	ME4130	Human Factors in Engineering and Design
42	ME3114	CAD/CAM/CIM
43	ME4131	Introduction to Turbulence

Department of Mechanical Engineering

Semester 3

No	Code	Subject	L	T	P	C	Category
1	MA2001	Mathematics III	3	1	0	3	BS
2	EE2009	Electrical Measurements and Machines	3	0	0	3	PT
3	ME2001	Mechanics of Fluids	3	0	0	3	PT
4	ME2002	Elements of Solid Mechanics	3	0	0	3	PT
5	ME2003	Engineering Mechanics – Dynamics	3	0	0	3	PT
6	ME2101	Materials Science and Metallurgy	3	0	0	3	PT
7	ME2091	Machine Drawing	0	0	3	2	PT
8	EE2094	Electrical Measurements and Machines Laboratory	0	0	3	2	PT
		Total	18	1	6	22	

SEMESTER 3

MATHEMATICS III MA2001 (PROBABILITY & STATISTICS)

L	T	P	C
3	1	0	3

Prerequisite: MA 1001 **Total Hours: 56 Hrs**

Module 1:

Probability distributions (15 Hours) Random variables, Binomial distribution, Hyper- geometric distribution, Mean and variance of a probability distribution, Chebyshev‘s theorem, Poisson distribution, Geometric distribution, Normal Distribution, Uniform distribution, Gamma distribution, Beta distribution, Weibull distribution. Joint distribution of two random variables.

Module 2:

Sampling distributions and Inference concerning means (14 Hours) Population and samples, The sampling distribution of the mean (σ known and σ unknown), Sampling distribution of the variance, Maximum Likelihood Estimation, Point estimation and interval estimation, point estimation and interval estimation of mean and variance, Tests of hypothesis, Hypothesis concerning one mean, Inference concerning two means.

Module 3:

Inference concerning variances proportions (13Hours) Estimation of variances , Hypothesis concerning one variance, Hypothesis concerning two variances , Estimation of proportions , Hypothesis concerning one proportion , Hypothesis concerning several proportions, Analysis of r x c tables, Chi – square test for goodness of fit.

Module 4:

Regression Analysis (14 Hours) Bi-variate Normal distribution- joint, marginal and conditional distributions. Curve fitting, Method of least squares, Estimation of simple regression models and hypothesis concerning regression coefficients, Correlation coefficient- estimation of correlation coefficient, hypothesis concerning correlation coefficient. Estimation of curvilinear regression models, Analysis of variance:- General principles, Completely randomized designs, Randomized block diagram, Latin square designs, Analysis of covariance.

Text Book

Johnson, R. A., Miller and Freund‘s Probability and Statistics for Engineers, 6th edition., PHI, 2004.

References

1. Levin R. I. & Rubin D. S., Statistics for Management, 7th edition, PHI, New Delhi, 2000. 2. S.M. Ross, Introduction to Probability and statistics for Engineers, 3rd edition, Academic Press(Elsevier), Delhi, 2005.

ELECTRICAL MEASUREMENTS AND MACHINES (EE2009)

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total Hours: 42

Module 1 (9 hours)

Electromechanical Energy Conversion principles - Types of machines - Basics of rotating machines - Construction - Rotating magnetic field - Principles of operation - Emf and torque equation - Losses and efficiency.

Module 2 (12 hours)

DC Machines: principle of operation – generators and motors – classification –characteristics - starter - speed control - load test - Swinburne's test - applications**.**

Transformers: Transformer Construction – principle of operation-equivalent circuit – regulation – efficiency – OC and SC tests –introduction to three phase transformer.

Module 3 (15 hours)

Alternators: Types, principle of operation - Synchronous motors: Principle of operation- starting- applications- Introduction to power Generation, Transmission and distribution system.

Induction Motors: Principle of operation – types – tests – Torque slip and performance characteristics – starting – speed control schemes – applications.

Single phase and special machines: FHP induction motors – universal motors - stepper motors – servo motors - tacho generators.

Module 4 (6 hours)

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

References

1. Hughes, K, *Electrical Technology*, E.L.B.S., 1996.
2. Nagrath, I.J, Kothari D.P, *Electrical Machines*, Tata McGraw-Hill Publishing Company Limited-New Delhi,1997.
3. Cotton, H., *Advanced Electrical Technology*, CBS Publishers and Distributors, New Delhi,1984.
4. Vincent Del Toro, *Electrical Machines & Power systems*, Prentice Hall, 1998.
5. Chapman, S.J, *Electric Machines & Power systems*, McGraw Holl,1999.
6. Say, M.G, *Alternating Current Machines*, Pittman, 1983.
7. Vertnott, C.C., *Fractional & sub-fractional Horse-power Electric Motors*, McGraw Hill, New York, 1978.
8. Sawhney, A.K, *Electrical & Electronic Measurements & Instrumentation*, Dhanpat Rai & Sons, 1996.
9. Gupta, B.R & Vandana Singhal, *Fundamentals of Electric machines*, D. K Publishets, New Delhi, 2000.
10. Soni, Gulpta & Bhatnagar, *A course in Electric Power*, Dhanpat Rai & Sons.

MECHANICS OF FLUIDS (ME2001)

Pre requisite: ME1001 Introduction to Mechanical Engineering

Total hours: 42

L	T	P	C
3	0	0	3

Module 1 (13 hours)

Preliminaries, Concept of continuum, Properties of fluids – density – pressure – viscosity - surface tension - capillarity - vapour pressure, Fluid statics, Basic equations of fluid statics, Variation of pressure in a fluid, - Manometry - Forces on surfaces and bodies in fluids, Floatation - stability of bodies in fluid - metacentric height and its measurement, Fluids in rigid body motion, Fluid kinematics -Eulerian and Lagrangian description - local and material rates - deformation of a fluid element -strain rate-velocity relations, Graphical description of flow – streamlines - path lines - streak lines - stream tube, Fluid dynamics - concept of the control volume -Reynolds transport equation and its use to formulate fluid mechanics problems, Integral and differential forms of the continuity - momentum and energy equations, Illustrative examples.

Module 2 (11 hours)

One dimensional flow through pipes, Non viscous equation for the flow through a stream tube and along a stream line – Euler‘s equation – Bernoulli‘s equation, - Energy equation, Applications of the one dimensional equations - velocity and flow measuring devices and quasi steady problems, Laminar and turbulent flow through pipes - Hagen-Poiseuille equation - Darcy-Weisbach equation - pipe friction -Moody‘s chart - minor losses in pipes

Module 3 (10 hours)

Two dimensional incompressible inviscid flows – Vorticity - Vortex tube - 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 over a cylinder, Magnus effect and the calculation of lift on bodies.

Module 4 (8hours)

Plane viscous flow past bodies, The boundary layer - Prandtl‘s boundary layer equations, Blasius solution for the boundary layer over a flat plate, Karman‘s Momentum Integ ral equations - Solutions using simple profiles for the boundary layer on flat plate - calculation of skin friction drag.

Reference Books

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

ELEMENTS OF SOLID MECHANICS (ME2002)

Prerequisite: ZZ1001 Engineering Mechanics

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (12 hours)

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

Module 2 (10 hours)

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

Module 3 (10 hours)

Torsion - torsion of circular elastic bars, statically indeterminate problems, torsion of inelastic circular bars, strain energy in torsion, Torsion of thin walled tubes, Deflection of beams - direct integration method, singularity functions, superposition techniques, moment area method , elementary treatment of statically indeterminate beams.

Module 4 (10 hours)

Transformation of stresses and strains (two-dimensional case only) - equations of transformation - principal stresses, Mohr's circles of stress and strain, Strain rosette, Compound stresses - superposition and its limitations - eccentrically loaded members, Columns - theory of columns - buckling theory - Euler's formula - effect of end conditions - eccentric loads and secant formula.

References

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

ENGINEERING MECHANICS – DYNAMICS (ME2003)

Prerequisite: ZZ1001 Engineering Mechanics

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (13 hours)

Review of particle kinematics, Velocity and acceleration in rectangular coordinates – cylindrical coordinates – path variables, Review of particle dynamics – Newton's Law for rectangular coordinates – cylindrical coordinates and path variables, Newton's Law for system of particles – review of work-energy relations for a single particle – work-energy equations for system of particles – work-energy expression based on center of mass, Linear momentum considerations for a system of particles – impulsive forces – impact, Moment-of-momentum equation for a single particle – moment-of-momentum for a system of particles.

Module 2 (8 hours)

Kinematics of rigid bodies, Translation and rotation of rigid bodies – Chasles' theorem – derivative of a vector fixed in a moving reference – applications of the fixed-vector concept – general relationship between time derivatives of a vector for different references – relationship between velocities of a particle for different references – acceleration of a particle for different references.

Module 3 (9 hours)

Moments and products of inertia – formal definition of inertia quantities – translation of coordinate axes – transformation properties of inertia terms – inertia ellipsoid and principal moments of inertia, Kinetics of plane-motion of rigid bodies, Moment-of-momentum equations – pure rotation of a body of revolution – body with two orthogonal planes of symmetry – slablike bodies – rolling of slablike bodies, General plane motion of a slablike body – pure rotation of an arbitrary rigid body – balancing.

Module 4 (12 hours)

Energy and impulse momentum methods for rigid bodies, Kinetic energy of rigid body – work-energy relations – angular momentum of a rigid body about any point in the body – impulse-momentum equations – impulsive forces and torques, Eccentric impact, Dynamics of general rigid-body motion – Euler's equations of motion and applications – necessary and sufficient conditions for equilibrium of rigid body – three-dimensional motion about a fixed point – Euler angles – equations of motion using Euler angles – torque-free motion.

References

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

MATERIALS SCIENCE AND METALLURGY (ME2101)

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (9 hours)

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

Module 2 (10 hours)

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

Module 3 (11 hours)

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

Module 4 (12 hours)

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

References

1. Smith, O.C., *Science of Engineering Materials,* 3rd ed., Prentice Hall, 1985.
2. Callister, W.D., *Materials Science and Engineering: An Introduction,* 7th ed., John Wiley & Sons, 2007.
3. Avner, S.H., *Introduction to Physical Metallurgy,* 2nd ed., McGraw-Hill Inc., 1976.
4. Van Vlack, L.H., *Elements of Materials Science and Engineering,* 6th ed., Addison Wesley Publishing Company, 1989.
5. Shackelford, J.F., *Introduction to Materials Science for Engineers,* 6th ed., Prentice Hall, 2004.
6. Higgins, R.A., *Engineering Metallurgy Part I, Applied Physical Metallurgy,* 6th ed., Viva Books Private Limited, 1998.
7. Raghavan, V., *Material Science and Engineering,* 5th ed., Prentice-Hall of India, 2004.
8. Reed Hill, R.E., *Physical Metallurgy Principles,* 2nd ed., Affiliated East-West Press, 2008.
9. Jastrzebski, Z.D., *Nature and Properties of Engineering Materials,* 2nd ed., John Wiley & Sons, 1976.
10. Charles, J.A., Crane, F.A.A., and Furness, J.A.G., *Selection and Use of Engineering Materials,* 3rd ed., Butterworth Heinemann, 1997.

MACHINE DRAWING (ME2091)

Prerequisite: ZZ1002 Engineering Graphics

L	T	P	C
0	0	3	2

Total Hours: 42

Module 1 (9 hours)

Introduction to machine drawing, Principles of orthographic projections applied to machine drawing, First angle and third angle projections, Methods of dimensioning, Conversion of pictorial projections into orthographic projections, Sectional views, Rules and conventions of sectioning, Full sectional, half sectional, partial sectional and revolved sectional views of simple machine parts, Screwed fastenings – screw thread forms – vee and square threads – nomenclature of threads – conventional representation of threads, Hexagonal and square headed bolts and nuts, Locking arrangements of nuts, Various types of machine screws and set screws, Foundation bolts.

Module 2 (9 hours)

Pipe joints – coupler joint – nipple joint – union joint – socket and spigot point – integral and screwed flanged joints, Shaft joints – cotter and pin joints – socket and spigot joint – gib and cotter joint – sleeve and cotter joint and knuckle joint, Couplings – muff couplings, flanged couplings, flexible coupling, Oldham's coupling and universal coupling, Parallel and tapered sunk keys – hollow and flat saddle keys – feather key and pin key, Bearings – solid journal bearings – bushed bearings – Plummer block – foot step bearing and pedestal bearing.

Module 3 (15 hours)

Assembly drawings – types – accepted norms, I.C. engine parts – piston – connecting rod, Steam Engine parts – eccentric – stuffing box, Parts of a lathe – tail stock – tool post, Miscellaneous assemblies – vices – screw jack, Valves.

Module 4 (9 hours)

Surface texture – nomenclature of surface texture – designation of surface texture – selection of surface characteristics, Limits, fits and tolerances – nomenclature – classification of fits – systems of fits and tolerances – designation – selection of fits and tolerances, Working/Production drawings – working drawings of simple machine elements, Computer aided drafting, Simple exercises using CAD Packages.

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.

ELECTRICAL MEASUREMENTS AND MACHINES LABORATORY (EE2094)

Prerequisite: Nil

L	T	P	C
0	0	3	2

Total Hours: 42

List of Experiments

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

References

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

Department of Mechanical Engineering

Semester 4

No	Code	Subject	L	T	P	C	Category
1	MA2002	Mathematics IV	3	1	0	3	BS
2	ME2011	Fluid Machinery	3	0	0	3	PT
3	ME2012	Applied Mechanics of Solids	3	0	0	3	PT
4	ME2013	Mechanics of Machinery	3	0	0	3	PT
5	ME2014	Thermodynamics	3	0	0	3	PT
6	ME3003	Environmental Studies for Mechanical Engineers	3	0	0	3*	OT
7	ME2092	Fluid Mechanics & Fluid Machinery Laboratory	0	0	3	2	PT
8	CE2095	Strength of Materials Laboratory	0	0	3	2	PT
		Total	18	1	6	22	

SEMESTER 4

MA2002 MATHEMATICS IV

Prerequisite: MA 1001, MA 1002

L	T	P	C
3	1	0	3

Total Hours: 56 Hrs

Module 1 Series Solutions and Special Functions (15 Hours)

Power series solutions of differential equations, Theory of power series method, Legendre Equation, Legendre Polynomials, Frobenius Method, Bessel's Equation, Bessel functions, Bessel functions of the second kind, Sturm-Liouville's Problems, Orthogonal eigenfunction expansions.

Module 2 Partial differential Equations (16 Hours)

Basic Concepts, Cauchy's problem for first order equations, Linear Equations of the first order, Nonlinear Partial Differential Equations of the first order, Charpit's Method, Special Types of first order equations, Classification of second order partial differential equations, Modelling: Vibrating String, Wave equation, Separation of variables, Use of Fourier Series, D'Alembert's Solution of the wave equation, Heat equation: Solution by Fourier series, Heat equation: solution by Fourier Integrals and transforms, Laplace equation, Solution of a Partial Differential Equations by Laplace transforms.

Module 3 Complex Numbers and Functions (13 Hours)

Complex functions, Derivative , Analytic function, Cauchy- Reimann equations, Laplace's equation, Geometry of Analytic functions: Conformal mapping, Linear fractional Transformations, Schwarz - Christoffel transformation, Transformation by other functions.

Module 4 Complex Integration (12 Hours)

Line integral in the Complex plane, Cauchy's Integral Theorem, Cauchy's Integral formula, Derivatives of analytic functions.Power series, Functions given by power series, Taylor series and Maclaurin's series. Laurent's series, Singularities and Zeros, Residue integration method, Evaluation of real Integrals.

Text Book

Kreyszig E, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons, New York, 1999 .

Reference Books

1. I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006. 2 .
Wylie C. R. & Barret L. C., Advanced Engineering Mathematics, 6th Edition,
Mc Graw Hill, New York,1995.
3. Donald W. Trim, Applied Partial Differential Equations, PWS – KENT publishing company, 1994.

ME2011 FLUID MACHINERY

L	T	P	C
3	1	0	3

Prerequisite: ME2001 Mechanics of Fluids

Total Hours: 42

Module 1 (11 hours)

Integral form of continuity, momentum and energy equations, Dynamic action of fluids over flat plates and curved surfaces – Force, work done and efficiency, Dimensional analysis – Rayleigh's method and Buckingham's pi method, Principles of models and similitude as applied to turbo-machines – Non-dimensional parameters applicable to hydraulic machines like capacity coefficient, head coefficient, power coefficient and specific speed and as applicable to hydraulics like Reynolds number, Mach number, Froude's number, Weber's number and Euler's number.

Module 2 (11 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, Model studies, Theory of draft tubes and cavitations in turbines.

Module 3 (11 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, Model studies, Cavitations in pumps.

Module 4 (9 hours)

Positive displacement pumps - Reciprocating pump – principle of working – Effect of acceleration and friction – Use of air vessels, Cavitation, Pump characteristics. Rotary pumps – Working principle of rotary piston pump, vane pump and gear pump, Miscellaneous fluid devices – Intensifier and Accumulator, Application to hydraulic devices – Hydraulic ram.

References:

1. Shepherd D.G., *Principles of Turbo machinery*, Macmillan Company, New York, 1956.
2. Jagdish Lal, *Hydraulic Machines*, 6th ed., Metropolitan book Co. private Ltd. New Delhi.
3. Stepanof, A.J., *Centrifugal and Axial Flow Pumps*, 2nd edition, John Wiley & Sons Inc., New York, 1957.
4. Dixon, S.L, Hall, C.A., *Fluid Mechanics and Thermodynamics of Turbo machinery*, Pergamon Press, 4th ed., 1998.
5. John. M. Vance, *Rotodynamics of Turbomachinery*, Wiley-Interscience Publication, John Wiley & Sons, 1988.
6. Cengel, Y.A, Cimbala, J.M., *Fluid Mechanics: Fundamentals & Applications*, 2nd ed., McGraw-Hill, 2006.

ME2012 APPLIED MECHANICS OF SOLIDS

Prerequisite: ME2002 Elements of Solid Mechanics

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 hours)

Stress at a point, Stress tensor, Stress transformation, Principal stresses – principal planes, Mohr‘s circle, Octahedral stresses, Hydrostatic and pure shear states, Strain at a point – strain tensor, Analogy with stress tensor.

Module 2 (11 hours)

Equations of elasticity - equation of equilibrium - strain-displacement equations, compatibility conditions - constitutive equations -Navier equations**,** Boundary conditions – traction - displacement and mixed boundary conditions. Special problems in bending - usymmetric bending - shear centre.

Module 3 (10 hours)

Simplification to 2-D problems - plane stress problems - plane strain problems, Axisymmetric problems - Lame‘s problem - rotating disks and shrink fits.Energy Techniques - introduction to energy methods - strain energy - principle of virtual work - minimum potential energy principle**.**

Module 4 (10 hours)

Three dimensional problems, Torsion of non-circular sections - St. Venant‘s theory - Prandtl‘s stress function approach - elliptical and triangular cross sections, Prandtl‘s membrane analogy, Torsion of thin walled open and closed sections.

Introduction to plasticity - theory of plasticity - yield criteria for metals - stress strain relationships. **References**

1. L. S. Srinath, *Advanced Mechanics of Solids*, Third edition, Tata McGraw Hill, 2003.
2. Den Hartog, *Advanced Strength of Materials*, McGraw Hill, New York.
3. S.P.Timoshenko and J.N. Goodier, *Theory of elasticity*, McGraw Hill International Edn., Third Edn., 1970.
4. A.J. Durelli, E.A. Philips and C.H. Psao, *Introduction to the Theoretical and Experimental Analysis of Stress and Strain*, McGraw Hill, New York.
5. Fred B. Seely and Smith, *Advanced Mechanics of Materials*, John Wiley and sons, New York.
6. W. Johnson, and P. B. Mellor, *Engineering Plasticity*, Van Nostrand Reinhold, 1973.

ME2013 MECHANICS OF MACHINERY

Prerequisite: ZZ1001 Engineering Mechanics

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (12 hours)

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

Module 2 (10 hours)

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

Module 3 (10 hours)

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

Module 4 (10 hours)

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

References

1. Uicker, J.J.Jr., Pennock, G.R., and Shigley, J.E., *Theory of Machines and Mechanisms*, 3rd ed., Oxford University Press, 2009.
2. Sandor, G.N., and Erdman, A.G., *Advanced Mechanism Design: Analysis and Synthesis, Vol. I & II*, Prentice-Hall of India, 1988.
3. Mabie, H.H., and Reinholtz, C.F., *Mechanisms and Dynamics of Machinery*, 4th ed., John Wiley & Sons, 1987.
4. Ghosh, A, and Mallik, A.K., *Theory of Mechanisms and Machines*, 3rd ed., Affiliated East-West Press, 1998.
5. Waldron, K.J., and Kinzel, G.L., *Kinematics, Dynamics and Design of Machinery*, John Wiley & Sons, 2004.
6. Norton, R.L., *Design of Machinery*, Tata McGraw-Hill, 2004.
7. Martin, G.T., *Kinematics and Dynamics of Machines*, McGraw-Hill, 1969.
8. Rattan, S.S., *Theory of Machines*, 4th ed., 2017, Tata McGraw-Hill, 2009.
9. Nikravesh, P.E., *Planar Multibody Dynamics*, CRC Press, 2008.

ME2014 THERMODYNAMICS

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (12 hours)

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

Module 2 (10 hours)

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 systems – energy balance for steady-flow systems – some steady-flow engineering devices – energy balance for unsteady-flow processes.

Module 3 (10 hours)

The second law of thermodynamics – introduction to the second law – thermal energy reservoirs – heat engines – Kelvin-Planck statement – energy conversion efficiencies – refrigerators and heat pumps – Clausius statement – equivalence of the two statements, Reversible and irreversible processes, The Carnot cycle, The Carnot principles, The thermodynamic temperature scale, The Carnot heat engine, The Carnot refrigerator and heat pump.

Module 4 (10 hours)

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, Reversible work and irreversibility, Second law efficiency, Thermodynamic property relations – the Maxwell relations – the Clapeyron equation – genral relations for du, dh, ds, C_v, and C_p, The Joule-Thomson coefficient, The h , u , and s of real gases.

References

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

ME3003 ENVIRONMENTAL STUDIES FOR MECHANICAL ENGINEERS

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (9 hours)

Scope and importance of Environmental Studies, Ecosystems – Structure and function, Forest, Grassland and Desert ecosystems, diversity in ecosystems, Value of biodiversity, Threats to biodiversity – Wildlife Protection Act – Forest Conservation Act, Conservation of biodiversity, Environmental ethics, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust.

Module 2 (11 hours)

Natural resources and associated problems: Forest resources, Aquatic ecosystems, Water resources, Mineral resources, Land resources, Causes, effects and control measures of Water pollution, Soil pollution and Marine pollution, Water (Prevention and control of Pollution) Act, Water conservation, rain water harvesting, watershed management, Disaster management: floods, earthquake, cyclone and landslides, Solid Waste Management: Causes, effects and control measures of urban and industrial wastes, Wasteland reclamation – Consumerism and waste products.

Module 3 (10 hours)

Environmental Pollution – Definition – Causes, effects and control measures of: - Air Pollution, Noise pollution, Thermal pollution and nuclear hazards, Environmental Protection Act – Air (Prevention and Control of Pollution) Act – Issues involved in enforcement of environmental legislation.

Module 4 (7 hours)

Renewable and non-renewable resources, Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources, From Unsustainable to Sustainable development – Urban problems related to energy, Role of an individual in conservation of natural resources, equitable use of resources for sustainable lifestyles – Role of Information Technology in Environment and human health.

Field work (Equal to 5 lecture hours)

Visit to a local area to document environmental assets-river/forest/grassland/hill/mountain – Visit to a local polluted site – Urban/Rural/Industrial/Agricultural – Study of common plants, insects, birds – study of simple ecosystems-pond, river, hill slopes, etc.

References

1. Agarwal, K.C., *Environmental Biology*, Nidi Publ. Ltd., Bikancr, 2001.
2. Bharucha Erach, *The Biodiversity of India*, Mapin Publishing Pvt. Ltd, Ahmedabad, India.
3. Brunner, R.C., *Hazardous Waste Incineration*, McGraw-Hill Inc.480p. , 1989.
4. Clark, R.S., *Manne Pollution*, Clanderson Press Oxford.
5. Cunningham, W.P., Cooper, T.H., Gorhani, E., and Hepworth, M.T., *Environmental Encyclopedia*, Jaico Publ. House, Mumbai, 1196p., 2001.
6. De A.K., *Environmental Chemistry*, Wiley Eastern Ltd.
7. Gleick, H.P., *Water in crisis, Pacific Institute for Studies in Dev. Environment and Security*. Stockholm Env. Institute. Oxford Univ. Press, 473p., 1993.
8. Heywood, V.H and Watson, R.T., *Global Biodiversity Assessment*, Cambridge Univ. Press, 1140p. 1995.
9. Jadhav, H and Bhosale, V.M.. *Environmental Protection and Law*, Himalaya -Pub. House, Delhi 284 p. 1995.
10. Mckinney, M.L., and Schocr, R.M, 199p., *Environmental Science systems and Solutions*, Web enhanced edition. 63.9p.
11. Mhaskar, A.K, *Matter Hazardous*, Techno-Science Publications.
12. Miller, T.G. Jr., *Environmental Science*, Wadsworth Publishing Co.
13. Odum, E.P., *Fundamentals of Ecology*, W.B., Saunders Co., USA, 574p., 1971.
14. Rao, M.N, and Datta, A.K., *Waste Water treatment*. Oxford & IBH Publ. Co., 345p. 1987.
15. Sharma, B.K., *Environmental Chemistry*, Goel Publ. House, Meerut, 2001.
16. Townsend, C., Harper, J, and Michael Begon, *Essentials of Ecology*, Blackwell Science.
17. Trivedi, R.K., *Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards*, Vol. I and II, Enviro Media (R).
18. Trivedi , R.K., and Goel, P.K., *Introduction to air pollution*, Techno-Science Publications.
19. Wagner, K.D., *Environmental Management*, W.B. Saunders Co., Philadelphia, USA, 499p., 1998.
20. Bharucha Erach, Textbook of Environmental Studies for undergraduate courses, 2nd ed., 2013.

ME2092 FLUID MECHANICS AND FLUID MACHINERY LABORATORY

Prerequisite: ME2001 Mechanics of Fluids

Total Hours: 42

L	T	P	C
0	0	3	2

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

CE2095 STRENGTH OF MATERIALS LABORATORY

L	T	P	C
0	0	3	2

Prerequisite: CE2001 Mechanics of Solids or equivalent.

Total Hours: 42

List of Exercises

1. Tension test on MS rod
2. Shear Test on MS rod
3. Torsion test on MS Specimen
4. Hardness tests on metals
5. Impact tests on metals
6. Bending test on steel beams
7. Spring test – open and close coil springs
8. Compression test on cubes and cylinders – determination of modulus of elasticity
9. Study of extensometers and strain gauges

Department of Mechanical Engineering

Semester 5

No	Code	Subject	L	T	P	C	Category
1	ME3001	Dynamics of Machinery	3	0	0	3	PT
2	ME3002	Principles of Heat Transfer	3	0	0	3	PT
3	ME3101	Management of Production Systems	3	0	0	3	PT
4	ME3102	Manufacturing Science	3	0	0	3	PT
5	ME3011	Gas Dynamics	3	0	0	3	PT
6	ME4101	Operations Research	3	0	0	3	HL
6	ME3091	Heat Transfer Laboratory	0	0	3	2	PT
7	ME3191	Production Engineering Laboratory I	0	0	3	2	PT
		Total	18	0	6	19+3*	

SEMESTER 5

ME3001 DYNAMICS OF MACHINERY

Prerequisite: ME2013 Mechanics of Machinery

Total hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 Hours)

Static force analysis of machines, Static force analysis with friction, Force analysis of gears, spur ─ helical ─ bevel, Method of virtual work, Dynamic force analysis, Principle of super position, Complex algebra method.

Module 2 (12Hours)

Balancing ─ Static and dynamic unbalance, Balancing of rotating masses – Balancing machines, Balancing of single cylinder engines – Balancing of multi cylinder engines – Balancing of V and radial engines, Balancing of linkages, Gyroscopes and its applications, Cam dynamics, Governors, Flywheels.

Module 3 (10Hours)

Recap of the Single DOF vibration systems – free and forced vibration – equivalent viscous damping, Transient vibration, Rotating unbalance, Support excited vibration, Critical speed of shafts, Vibration measuring instruments, Vibration of two DOF systems – formulation-normal mode analysis – solution of matrix Eigen value problem.

Module 4 (10 Hours)

Two DOF ─ Forced harmonic vibration, Vibration absorber, Multi DOF systems ─ matrix formulation, Lagrange‘s equation, Introduction to vibration of continuous systems ─ vibration of string, Approximate methods – Rayleigh‘s energy method ─ Dunkerley's equation, Holzer‘s method, Geared system.

References

1. Uicker, J.J. Jr., Pennock, G.R., and Shigley, J.E., *Theory of Machines and Mechanisms*, 3d ed., Oxford University Press, 2009.
2. Mabie, H.H., and Reinholtz, C.F., *Mechanisms and Dynamics of Machinery*, 4d ed., John Wiley & sons, 1987.
3. Ghosh, A, and Mallik, A.K., *Theory of Mechanisms and Machines*, 3d ed., Affiliated East-West Press, 1998.
4. Holowenko, A.R., Dynamics of Machinery, John Wiley & Sons, 1965.
5. Waldron, K. J., and Kinzel, G. L., *Kinematics, Dynamics and Design of Machinery*, John Wiley & Sons, Inc., 2004.
6. Norton, R.L., *Design of Machinery*, Tata McGraw-Hill, 2004.
7. Rattan, S.S., *Theory of Machines*, 3d ed., Tata McGraw-Hill, 2009.
8. Nikravesh, P.E., *Planar Multibody Dynamics*, CRC Press, 2008.
9. Thomson, W.T., Dahleh, M.D., and Padmanabhan, C, 5d ed., *Theory of Vibrations with Applications*, Pearson Education, 2008.
10. Meirovitch, L., *Elements of Vibration Analysis*, 2d ed., McGraw-Hill, 2007.
11. Den Hartog, J.P., *Mechanical Vibrations*, 4d ed., McGraw-Hill, 1985.

ME3002 PRINCIPLES OF HEAT TRANSFER

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Heat transfer - basic modes of heat transfer , conduction heat transfer , energy balance -integral and differential approaches , 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

Module 2 (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 - similarity and integral formulation of natural convection heat transfer from vertical plates , empirical relations in free convection., Condensation and boiling - film and drop wise condensation - film boiling and pool boiling, empirical relations for heat transfer with phase change, Introduction to mass transfer - Fick's law of diffusion – mass transfer coefficient - analogy between momentum, heat and mass transfer.

Module 3 (10 hours)

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

Module 4 (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. Applications of radiative heat transfer, Multiple- mode heat transfer problems.

References

1 Holman, J.P., *Heat Transfer*, 9th ed., Tata McGraw Hill, 2005.

2 Incorpera, F.P., De Witt, D.P., Bergman T.L. and Lavine A.S., Principles *of Heat and Mass Transfer*, Wiley India Private Limited, 2003.

3 Kreith, F., *Heat Transfer*, International Text Book Company.

4 Gebhart, B., *Heat Transfer*, McGraw Hill.

ME3101 MANAGEMENT OF PRODUCTION SYSTEMS

Pre-requisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (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, Production planning and control – framework, Material requirement planning (MRP) – technical issues – system dynamics, Production activity control.

Module 2 (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 3 (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 4 (10 Hours)

Quality management, Quality costs, Introduction to TQM, Introduction to six sigma, Statistical process control, Control charts for variables – X-bar and R chart, Control charts for attributes – P and C chart, Introduction to acceptance sampling.

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.

ME3102 MANUFACTURING SCIENCE

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 hours)

Foundry: foundry materials - moulding and core sand - binders - additives, sand preparation - sand control tests, pattern and pattern making, mould and core making, expendable and non expendable moulds, mould assembly, melting furnaces and melting practice, pouring and fettling, solidification of pure metals and alloys, grain growth.

Module 2 (11 hours)

Casting processes - sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, centrifugal casting, casting design, gateway system design, riser design casting alloys, casting defects, inspection, testing - destructive and non - destructive, casting alloys, economics of casting.

Module 3 (10 hours)

Yield criteria of metals (von Mises, Tresca), representation in stress space, isotropic hardening, kinematic hardening. Plastic stress strain relationship. Metal forming Operations, Principle, process and equipment for drawing, extrusion, rolling, forging. Analysis of forming operations - load calculation for drawing, extrusion, rolling, forging.

Module 4 (10 hours)

Metal joining - classification, welding heat sources, arc welding machines, arc production, arc characteristics, metal transfer, welding electrode, gas welding, resistance welding, thermit welding, ultrasonic welding, electron beam welding, laser beam welding, gas and arc cutting. Welding metallurgy, weldability of ferrous and non-ferrous metals, design of weldments, joint design, residual stresses and distortion, testing of welded joints, brazing and soldering.

References

1. Ghosh, A., and Mallik, A.K., *Manufacturing Science,* Affiliated East west Press Ltd, 2001.
2. Heine, R., Loper, C., and Rosenthal, P., *Principles of Metal Casting,* Tata McGraw Hill, 2004.
3. Little, R., *Welding and welding Technology,* Tata McGraw Hill, 2004.
4. Kalpakjian, S., *Manufacturing Engineering & Technology,* Addison Wesley Longman Limited, 1995.
5. Hoffman, O., and Sachs, G., *Introduction to Theory of Plasticity for Engineers,* McGraw-Hill Book Company, 1953.
6. Flemings, M.C., *Solidification Processes,* McGraw Hill, American Welding Society, Welding Hand Book.
7. Doyle, L.E., *Manufacturing Processes and Materials for Engineers, 3rd ed.,* Prentice Hall of India, 1984.
8. Taylor, H.F., Flemings, M.C., and Wulff, J., *Foundry Engineering,* 1st ed., John Wiley & Sons Inc, 1959.
9. *Metals Hand Book – Vol. 5,* Welding Institute of Metals, USA.

ME3011 GAS DYNAMICS

Prerequisite: ME2001 Fluid Mechanics

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (10 hours)

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

Module 2 (11 hours)

Introduction to compressible flows, Basic concepts - equations for one-dimensional flow through stream tubes - variation of pressure - temperature - density in the atmosphere, Speed of sound , Mach number, Qualitative difference between incompressible, Subsonic and supersonic flows, Karman's rules of supersonic flows,

Characteristic velocities, The adiabatic flow ellipse, Isentropic flow through a duct - criterion for acceleration and deceleration - stagnation quantities - isentropic relations, Use of gas tables and charts, Operation of nozzles at off-design conditions.

Module 3 (11 hours)

Normal shocks in one-dimensional flow - occurrence of shocks - analysis of normal shocks - Prandtl's equation - Rankine - Hugoniot equation and other normal shock relations - moving shocks, Oblique shocks and expansion waves - oblique shock relations - θ- βM relations - shock polar, Supersonic flow over a wedge - expansion waves - Prandtl- Meyer function - intersection of shocks - detached shocks - Mach deflection - shock expansion theory.

Module 4 (10 hours)

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

References

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

ME4101 OPERATIONS RESEARCH

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total Hours: 42

Module 1 (12 hours)

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

Module 2 (9 hours)

Duality in linear programming – Primal-dual relationships – Economic interpretation of duality, Transportation problems – formulation and solution, Assignment problems – formulation and solution.

Module 3 (9 hours)

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

Module 4 (12 hours)

Dynamic programming – characterization – Bellman's principle of optimality – problems with a finite number of concentric decisions, Queuing theory – generalized Poisson queuing model – steady state solution of single server models for infinite queue size and finite queue size.

References

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

ME3091 HEAT TRANSFER LABORATORY

L	T	P	C
0	0	3	2

Prerequisite : Nil

Total Hours: 42

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.

ME3191 PRODUCTION ENGINEERING LABORATORY I

L	T	P	C
0	0	3	1

Prerequisite: Nil

Total Hours: 42

Classifications of machine tools and machining processes - Specification of machine tool, power source, Centre lathe - general features, parts and functions - Machining on Centre lathe - Cutting tools - Materials, types: Grinding, Cutting variables - Selection of speeds, feeds and depth of cut - Use of cutting fluids - Methods of holding work - Lathe operations - straight, taper and eccentric turning, thread cutting, drilling, boring, profile turning, knurling - Tolerance and surface finish.

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.

Department of Mechanical Engineering

Semester 6

No	Code	Subject	L	T	P	C	Category
1	ME3111	Machining Science and Machine Tools	4	0	0	4	PT
2	ME3112	Metrology and Instrumentation	3	0	0	3	PT
3		Elective I	3	0	0	3	PT
4	ME3012	Thermal Engineering I	3	0	0	3	PT
5	ME4001	Machine Design I	3	0	0	3	PT
6	ME3192	Metrology and Instrumentation Laboratory	0	0	3	2	PT
7	ME3193	Production Engineering Laboratory II	0	0	3	2	PT
		Total	16	0	6	20	

SEMESTER 6

ME3111 MACHINING SCIENCE AND MACHINE TOOLS

Prerequisite: Nil

L	T	P	C
4	0	0	4

Total Hours: 56

Module 1 (14 hours)

Kinematic elements in metal cutting. Tool nomenclatures. Mechanics of chip formation, orthogonal and oblique cutting, shear angle, velocity relationship. Merchant's analysis of cutting forces, cutting power estimation. Inserts - chip groove geometries: nomenclature, selection and applications in turning, milling, drilling. Carbide grade design, carbide coatings. Advances in cutting tool materials. Effect of cutting variables on forces. Tool failure analysis, theories of tool wear, measurement of tool wear. Tool dynamometers, thermal aspects of machining, Tool life and economics of machining, CNC machining. Micro machining.

Module 2 (14 hours)

Basic concepts of machine tools: Tool - work motions, machine tools for various machining processes, kinematics of machine tools and gear boxes, feed and speed mechanism, machine tool drives, machine tool dynamics, gear manufacture - milling, hobbing and shaping, special purpose machine tools, hydraulic control of machine tools, components of hydraulic circuits, control circuits and their characteristics, testing of machine tools for positioning accuracy and repeatability.

Module 3 (14 hours)

CNC machine tools, constructional features, drives and controls, stepper motors, servo motors, hydraulic systems, feed back devices, counting devices, interpolators - linear, circular interpolation and other emerging techniques, adaptive control systems for turning and milling, CNC part programming, post processors, CNC programming with interactive graphics, use of various software packages, development of CNC programmes for special problems. Introduction to robotics.

Module 4 (14 hours)

Modern machining processes: Mechanics of AJM, EDM, USM, EBM and ECM, process parameters and applications. Jigs and fixtures, basic principles of location, type and mechanics of locating and clamping elements, design of jigs and fixtures.

References

1. Ghosh, A., and Mallik, A.K., *Manufacturing Science,* Affiliated East west Press Ltd, 2001.
2. Chattopadhyay A.B., Machining and Machine Tools, Wiley India Private Limited, 2nd ed.
3. Juneja, B.L., Sekhon, G.S., and Seth, N., *Fundamentals of Metal Cutting and Machine Tools,* 2nd ed., New Age International Publishers, 2003.
4. Sen and Bhattacharya, *Principles of Machine Tools,* New Central Book Agency (P) Ltd, 1975.
5. Bhattacharyya, A., *Metal Cutting: Theory and Practice,* New Central Book Agency (P) Ltd, 1984.
6. Shaw, M.C., *Metal Cutting Principles,* 2nd ed., Oxford University Press, 2005.
7. Kalpakjian, S., *Manufacturing Engineering & Technology,* Addison Wesley Longman Limited, 1995.
8. Mehta, N.K., *Machine Tool Design and Numerical Control,* 2nd ed., Tata Mc Graw Hill, 1996.
9. Boothroyd, G., Fundamentals of Metal Machining and Machine Tools, McGraw Hill, 1975.
10. ASTME, *Fundamentals of Tool Design,* Prentice-Hall of India.
11. Chapman, W.A.J., *Workshop Technology: Vol. 1, Vol. 2, Vol.3,* CBS Publishers & Distributors.
12. Khaimovich, Y.M., *Hydraulic control of Machine tools,* Pergamon Press.
13. Esposito, A., *Fluid Power with Applications,* 7th ed., Pearson Education, 2008.
14. Ernest, W., *Oil Hydraulics Power and its Industrial Applications,* 2nd ed., McGraw Hill Book Company, 1960.
15. Kempster, M.H.A., *An Introduction to Jig and Tool Design,* 3rd ed., Butterworth-Heinemann Ltd, 1974.
16. Donaldson, C., LeCain, G.H., and Goold,V.C., *Tool design,* 3rd ed., Tata Mc Graw Hill, 1973.
17. Koren, Y., *Computer Control of Manufacturing Systems,* Mc Graw Hill Book Company, 1986.
18. Groover, M.P., *Automation, Production Systems, and Computer-Integrated Manufacturing,* 3rd ed., Pearson Education, 2008.
19. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., *Robotics, Control, Sensing, Vision and Intelligence*, 1st ed., McGraw-Hill Book Company, 1987.

ME3112 METROLOGY AND INSTRUMENTATION

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (12 hours)

Measurement fundamentals: Units of measurement, terms used in measurement. Measurement uncertainty - Introduction, Standard deviation as a measure, combining standard uncertainties. Statistical concepts - Sampling, least squares model, covariance and correlation. Calculation of uncertainties - Law of propagation, correlated inputs, probability densities, sampling distributions, case studies and problems.

Module 2 (10 hours)

Experiment planning: Factors, Interference, Randomization, Repetition and Replication, Concomitant methods. Dynamic characteristics: General model, Zero order, First order - Step response and Frequency response, Second order- Step response and frequency response, Experimental determination of parameters.

Module 3 (10 hours)

Metrology: Dimensional and angular measurement - Slip gauges, Comparators, Abbe's principle. Pneumatic transducer, Electronic transducers, Sine bar, angle gauges. Surface finish - Parameters, Stylus instruments.

Module 4 (10 hours)

Instrumentation: Strain measurement- Resistance & semiconductor strain gauges, circuits and arrangements. Pressure measurements- Manometers, Elastic transducers. Force & Torque measurements. Temperature measurement - Expansion thermometers, Resistance Temperature Detectors, Thermistors, Thermocouples, radiative measurements.

References

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

Elective-1

ME4028 AERODYNAMICS

Prerequisite: ME2001 Fluid Mechanics

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 hours)

Equations for incompressible inviscid flows, Fluid circulation and rotation – vorticity - Kelvin‘s theorem - velocity potential - stream function - equation of a stream line - complex potential, Blasius theorem for force and moment on bodies, Elementary flow patterns and their superposition.

Module 2 (11 hours)

Flow past a cylinder - Magnus effect - Kutta condition - Vortex theory of lift. Conformal transformation, The Joukowski transformation - lift on arbitrary cylinder, Aerodynamic center, Pitching moment.

Module 3 (10 hours)

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

Module 4 (10 hours)

Finite wings - downwash and induced drag - Prandtl-Lachester theory - Biot- Savart law, General series solution, Glauret method, Multhop‘s method, Horseshoe effects, Ground effects, Lineraised compressible flows in two dimensions - flow past a wavy wall, Similarity rules, Aerofoil in compressible flows.

References

1. Anderson ,J.D., *Fundamentals of Aerodynamics*, 5th ed., McGraw Hill, New York, 1998
2. Kuethe,A.M., and Chow,C., *Foundations of Aerodynamics*, Fourth Edition, Wiley Eastern, New Delhi, 1986.
3. Katz,J.,and Plotkin,A., *Low Speed Aerodynamics*, McGraw Hill, New York, 1991.
4. Houghton,E.L., and Brock,A.E., *Aerodynamics for Engineering Students*, Edward Arnold, London, 1960.
5. Anderson, J.D. Joiner, *Introduction to Flight*, MaGraw Hill Education, 7th Ed, 2011.

ME4027 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

Prerequisite: Nil
Elective -1

Total Hours: 42

Module 1 (10 hours)

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

Module 2 (10 hours)

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

Module 3 (10 hours)

Computational Methods for one, two and three-dimensional heat equations - explicit, implicit, Crank-Nicholson, ADI schemes, ADE schemes, Fractional step methods, Hopscotch scheme, Douglass scheme, Conservative form of partial differential and finite difference equations, Methods to deal interface property and non linearity, Consistency, stability and convergence of computational methods, Discrete perturbation stability analysis, Von-Neumann stability analysis, Validation of computational solution.

Module 4 (12 hours)

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

References

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

ME3012 THERMAL ENGINEERING I

L	T	P	C
3	1	0	3

Prerequisite : Nil

Total Hours: 42

Module 1 (10 Hours)

Analysis of Gas power cycles, Value of Carnot cycle in engineering, Air standard cycles - assumptions – Otto - Diesel & Dual combustion cycles, Comparison among these cycles, Miller and Stirling cycles, Real air-fuel cycles, SI engine cycle at part throttle and supercharged conditions, Four stroke and Two stroke engines, Valve timing & Port timing diagrams, Scheme of scavenging - Scavenging efficiency.

Module 2 (11 Hours)

Classification of IC engines - Terminology, variables and abbreviations. Simple Carburettor, Fuel Injection Pump and Injectors. Engine systems – Intake and Exhaust, Transmission, Cooling, Lubrication, Ignition, Starting systems. Thermochemistry - Fuels for IC engines, Stoichiometric air, Equivalence Ratio, Self Ignition temperature, Ignition lag (delay), Normal combustion in SI engines, Engine knock – effect of variables on tendency to knock – Octane Number – Pre-ignition.

Module 3 (11 Hours)

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

Module 4 (10 Hours)

Analysis of Gas Turbine cycles - Brayton cycle, Regeneration - Reheat and Inter cooled cycles – Ericsson cycle – Ideal Jet – propulsion cycles, Modifications to turbojet engines, Actual Brayton cycle, Open and Closed cycles, Combustion chambers for gas turbines, A/F ratio and stability loop, Centrifugal and axial flow compressors.

References

1. Yunus A. Cengel and Michael A. Boles, *Thermodynamics – An engineering approach*, 3rd ed., Mc Graw-hill Professional, 1998
2. Willard W and Pulkrabek, *Engineering Fundamentals of Internal combustion Engines*,2nd ed., Phi Learning., New Delhi, 2009
3. Henry Cohen, Rogers G. F. C and Saravanamuttoo H. I. H, *Gas Turbines Theory*, 4th ed., Heritage Publishers, 1996
4. John B. Heywood, *Internal Combustion Engine Fundamentals*, 1st ed., McGraw-Hill, 1998.
5. Mathur L. and. Sharma R. P, *A Course in Internal combustion Engines*, 7th ed.,Dhanpat Rai Publications (P) Ltd., 1999.
6. Ganehan V, *Internal Combustion Engines*, MaGraw Hill Education, 2012

ME4001 MACHINE DESIGN – I

Prerequisite: ME2002 Elements of Solid Mechanics

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (12 hours)

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

Module 2 (10 hours)

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

Module 3 (10 hours)

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

Module 4 (10 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.

References

1. Shigley, J.E., *Mechanical Engineering Design*, 1st Metric ed., McGraw-Hill, 1986.
2. Shigley, J.E. and Mischke C.R., *Mechanical Engineering Design*, 6th ed., Tata McGraw-Hill, 2003.
3. Siegel, M.J., Maleev, V.L. and Hartman, J.B., *Mechanical Design of Machines*, 4th ed., International Textbook Company, 1965.
4. Phelan, R.M., *Fundamentals of Mechanical Design*, Tata McGraw-Hill,1967.
5. Doughtie, V.L. and Vallance, A.V., *Design of Machine elements*, McGraw-Hill, 1964.
6. Juvinall, R.C. and Marshek, K.M., *Fundamentals of Machine Component design*, 3rd ed., John Wiley & Sons, 2000.
7. Norton, R.L., *Machine Design*, 2nd ed., Pearson Education, 2000.
8. Bhandari, V. B., *Design of Machine Elements*, McGraw Hill Education India Pvt. Ltd. 4th Ed, 2017

Data Handbooks (allowed for reference during examinations also)

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

ME3192 METROLOGY AND INSTRUMENTATION LABORATORY

L	T	P	C
0	0	3	1

Prerequisite: Nil

Total Hours: 42

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

ME3193 PRODUCTION ENGINEERING LABORATORY II

L	T	P	C
0	0	3	1

Prerequisite: Nil

Total Hours: 42

Introduction: Limits and Fits, Horizontal and Vertical milling machine – Spindle drives and feed motion - Milling cutters – indexing head – Simple, compound and differential indexing, shaping machine - cutting motion, slotting machine, Grinding machine – Surface, cylindrical and centreless grinding – Tool and cutter grinder, unconventional machining, NC/CNC machine.

Exercises:

Shaping and slotting Exercises - Flat and bevel surfaces, grooves, Slots, guide ways, key ways etc. Exercises in horizontal and - surface, slot, key way and gear milling - Vertical milling machine. Turning Exercises - Limits and Fits. Grinding Exercises. Non – traditional Machining, NC/CNC Machining.

References

1. HMT, *Production Technology,* Tata McGraw Hill, 2004.
2. ASTME, *Tool Engineer's Handbook.*
3. Chapman, W.A.J., *Workshop Technology: Vol. 2, Vol.3,* CBS Publishers & Distributors.
4. Rao, P.N., *Manufacturing Technology: Metal Cutting & Machine Tools,* 2nd ed., Tata McGraw Hill, 2008.
5. Groover, M.P., and Zimmers, E.W., *CAD/CAM: Computer-Aided Design and Manufacturing,* 1984.
6. Mehta, N.K., *Machine Tool Design and Numerical Control,* 2nd ed., Tata McGraw Hill, 1996.

Semester 7

No	Code	Subject	L	T	P	C	Category
1	ME4002	Thermal Engineering II	3	0	0	3	PT
2		Elective II	3	0	0	3	PT
3	ME4011	Machine Design II	3	0	0	3	PT
4	MS4004	Industrial Economics	3	0	0	3	PT
5	ME4098	Project	0	0	3	3	PT
6	ME4091	Heat Engine Laboratory	0	0	3	2	PT
7	ME4191	CAD/CAM Laboratory	0	0	3	2	PT
		Total	12	0	9	19	

ME4002 THERMAL ENGINEERING – II

L	T	P	C
3	0	0	3

Prerequisite: ME2014 Thermodynamics

Total hours: 42 Hrs

Module 1 (12 hours)

Properties of steam – use of steam tables and Mollier chart – Separating and Throttling Calorimeter – properties of mixtures of steam and atmospheric air, Psychrometric chart, Solution of problems on evaporative cooling towers and wet cooling towers, Vapour and combined power cycle – Carnot vapour cycle – Ideal Rankine cycle – deviations in an actual Rankine cycle – methods to increase the efficiency of the Rankine cycle – Reheat and Regenerative cycles, Open and closed feedwater heaters – deaerator – co-generation – combined gas power cycles.

Module 2 (10 hours)

Steam generators – fire tube – Lancashire, Locomotive and Nestler boilers, Water-tube – Babcock and Wilcox and Bent-tube boilers, Mountings and accessories – schematic diagram of a modern steam generator – combustion equipment – over feed and under feed stokers – travelling-grate and spreader stokers – pulverized coal burners – cyclone furnace – fluidized-bed combustion, Steam nozzles – condition for maximum discharge – design for throat and exit areas – effect of friction – supersaturated flow.

Module 3 (10 hours)

Steam turbines – classification – impulse and reaction turbine – velocity diagrams – efficiencies – end thrust – blade height – turbine performance and governing, Condensers – purpose of a condenser in a steam power plant – surface and mixing condensers, Different types of modern wet and dry cooling towers.

Module 4 (10 hours)

Power Plant Economics – load curve and load duration curve – load, Diversity, Capacity and use factors – selection of size and number of units – scheduling of operation – depreciation and replacement – environmental aspects of thermal power systems, Dust collectors.

References

1. Y.A, Cengel, and M.A, Boles, *Thermodynamics - An engineering approach*, 4th ed., Tata McGraw Hill, New Delhi, 2005.
2. M.M, El-Wakil, *Power Plant Engineering*, 1st ed., McGraw Hill, New York, 1985.
3. W.A., Vopat, and B.G.A., Skrotzki, *Power Station Engineering and Econom.*, Tata McGraw Hill, New Delhi, 1999.
4. Husain, and Zoeb, *Steam turbines*, Tata McGraw Hill, 1984.
5. Nag. P.K., Power Plant Engineering, McGraw Hill Education 2008.

ME4011 MACHINE DESIGN – II

Prerequisite: ME2002 Elements of Solid Mechanics

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (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 – belt and chain drives of common types – design of flat and V-belt drives – selection of roller chains.

Module 2 (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 3 (11 hours)

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

Module 4 (7 hours)

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

References

1. Shigley, J.E., *Mechanical Engineering Design*, 1st Metric ed., McGraw-Hill, 1986.
2. Shigley, J.E. and Mischke C.R., *Mechanical Engineering Design*, 6th ed., Tata McGraw-Hill, 2003.
3. Siegel, M.J., Maleev, V.L. and Hartman, J.B., *Mechanical Design of Machines*, 4th ed., International Textbook Company, 1965.
4. Phelan, R.M., *Fundamentals of Mechanical Design*, Tata McGraw-Hill, 1967.
5. Doughtie, V.L. and Vallance, A.V., *Design of Machine elements*, McGraw-Hill, 1964.
6. Juvinall, R.C. and Marshek, K.M., *Fundamentals of Machine Component design*, 3rd ed., John Wiley & Sons, 2000.
7. Norton, R.L., *Machine Design*, 2nd ed., Pearson Education, 2000.
8. James G. Bralla, Handbook of Product Design for Manufacture, McGraw Hill
9. Bhandari, V. B., *Design of Machine Elements*, McGraw Hill Education India Pvt. Ltd. 4th Ed, 2017

Data Handbooks (allowed for reference during examinations also)

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

MS4004 INDUSTRIAL ECONOMICS

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42 Hrs

Module 1 (11 hours)

General Foundations of Economics; Nature of the firm; Forms of organizations-Objectives of firms-Demand analysis and estimation-Individual, Market and Firm demand, Determinants of demand, Elasticity measures and business decision making, Demand Forecasting-Theory of the firm-Production functions in the short and long run-Cost concepts- Short run and long run costs- economies and diseconomies of scale

Module 2 (9 hours)

Product Markets-Market Structure-Competitive market-Imperfect competition (Monopoly, Monopolistic competition and Oligopoly) and barriers to entry-Pricing in different markets-Differential Pricing-Supply, Demand and Government Policies-Game Theory-Prisoner‘s Dilemma

Module 3 (11 hours)

Macro Economic Aggregates-Gross Domestic Product; Economic Indicators; Models of measuring national income; Inflation ; Fiscal and Monetary Policies ; Monetary system; Money Market, Capital market; Indian stock market; Development Banks; Changing role of Reserve Bank of India

Module 4 (11 hours)

International trade - Foreign exchange market- Balance of Payments (BOP) and Trade-Effects of disequilibrium in BOP in business- Trade regulation- Tariff versus quotas- International Trade and development and role of international institutions (World Bank, IMF and WTO) in economic development.

References

1. Bo Soderston,International Economics,
2. Gupta, S.B Monetary Economics,. (1994). S. Chand & Co., New Delhi.
3. Gregory.N.Mankiw,Principles of Micro Economics, Cengage Publications,2007
4. Gregory.N.Mankiw ,Principles of Macro Economics, Cengage Publications,2007
5. *Indian Economy – Its Development Experience*, Misra, S.K. and V.K. Puri (2001)Himalaya Publishing House, Mumbai,2009.
6. *Microeconomics*, R.S. Pindyck, D.L Rubinfield and P.L. Mehta ,Pearson Education, 2005. *Advanced Economic Theory*, Micro Economics H.L. Ahuja,Chand Publications,2004.
7. Economics, Samuelson, P.A.;& W.D. Nordhaus , Tata McGraw Hill,18 Ed.,2005.
8. Public Finance , B.P.Tyagi,Jai PrakashNath & Co.,1997.
9. Ahuja, H.L. Advanced Micro Economics, 20th Revised Ed, S. Chand Publication.

PN : Supplementary materials would be suggested / supplied for select topics on Indian economy

ME4098 PROJECT

Prerequisite: Nil

Total Hours: 42

L	T	P	C
0	0	3	3

Students are required to take up a project (generally in groups) in any topic related to Mechanical Engineering under the guidance of a faculty member. The project work commenced in VII Semester (normally 5 hours/week) shall be continued in VIII Semester too. At the end of the VII semester, an interim report describing the details of the project work has to be submitted to the Department, usually in a prescribed format. Presentation of this part of the work is to be done before an evaluation committee.

ME4091 HEAT ENGINES LABORATORY

Prerequisite: Nil

Total Hours: 42

L	T	P	C
0	0	3	2

Study of spark ignition (SI) and compression ignition (CI) engine systems - fuel system - lubrication system - cooling system - starting system - ignition system - governing system - power transmission system - types of carburetors - fuel injectors - multi point fuel injection (MPFI) system - common rail direct injection (CRDI) system - gasoline direct injection (GDI) system, Study of different types of boilers and its components, Study of fuel properties measuring systems - bomb calorimeter - gas calorimeter - red-wood viscometer - flash and fire apparatus, Study of dynamometers, Constant speed performance characteristics of SI engine, Morse test at constant throttle and at constant load, Constant speed performance characteristics of SI engine, Constant speed performance characteristics of MPFI engine, Performance characteristics of constant speed CI engine, Constant speed performance characteristics of single cylinder CI engine, Determination of frictional horse power (FHP) by retardation test, Constant speed performance characteristics of reciprocating compressor, Variable speed performance characteristics of SI engine (with carburetor and MPFI system), Performance characteristics of CI variable speed engine, Determination of viscosity - flash and fire point - calorific value of the given fuel or oil, Performance characteristics of centrifugal blower and rotary type positive displacement compressor by suitable test, Performance characteristics with cooling water temperature (cooling curve experiment) by suitable test, Valve timing diagrams of single and multi cylinder engines.

ME4191 CAD/CAM LABORATORY

Prerequisite: Nil

L	T	P	C
0	0	3	1

Total Hours: 42

Introduction to Computer Graphics – Viewing transformations, Curves and Surfaces generation – Familiarity with Boolean operations – Sweep, Revolve, Loft, Extrude, Filleting, Chamfer, Splines etc. Windowing, View Point, Clipping, Scaling and Rotation Transformations. Usage of commercial solid modelling packages like Pro-E, CATIA, etc. Introduction to FEM-Mesh generation, Linear and Non Linear analysis-Static Dynamic analysis, Post Processing, Exercises on Heat Conduction, fluid flow and Elasticity. Usage of commercial FEM packages like ANSYS, ABAQUS etc. Synthesis and Design of Mechanisms - Animations, Exercises on various mechanisms like four bar linkages and its variations, cam and follower, Two and Four Stroke engines, Design for manufacturability - use of commercial software packages, Exercises in Process Control using PLC-PID control strategy, CNC Part Programming fundamentals - Manual Part Programming and Computer Aided Part Programming. Exercises on CNC Lathe and Machining Center/Milling machines, Rapid Prototyping, Hands on training on industrial robots-manual and programmed path planning, Demonstration of the capability of Coordinate Measuring Machine using sample component e.g.: Engine Block – Concepts of Reverse Engineering and Rapid Prototyping.

References

1. Rogers, D.F., and Adams, J.A., *Mathematical Elements for Computer Graphics*, 2nd ed., Tata McGraw Hill, 2009.
2. Rogers, D.F., *Procedural Elements for computer Graphics*, 2nd ed., Tata McGraw Hill, 1997.
3. Cook R.D., Malkus, D.S., Plesha, M.E., and Witt, R.J., *Concepts and Applications of Finite Element Analysis*, 4th ed., John Wiley & Sons, 2001.
4. Koren, Y., *Computer Control of Manufacturing Systems*, McGraw Hill Book Company, 1986.
5. Rao, P.N., Tewari, N.K., and Kundra, T.K., *Numerical Control & Computer Aided Manufacturing*, Tata McGraw Hill.
6. Ramamurthy, V., *Computer Aided Mechanical Design and Analysis*, 4th ed., Tata McGraw Hill, 2000.
7. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., *Robotics, Control, Sensing, Vision and Intelligence*, 1st ed., McGraw-Hill Book Company, 1987.
8. Koren, Y., *Robotics for Engineers*, Tata McGraw Hill, 1985.
9. Bosch, J.A., *Coordinate measuring Machines &Systems*, Marcel Decker Inc., New York.

Semester 8

No	Code	Subject	L	T	P	C	Category
1		Elective III	3	0	0	3	PT
2	ME2111	Essential of Management	3	0	0	3	PT
3		Elective IV	3	0	0	3	PT
4		Elective V	3	0	0	3	PT
5	ME4099	Project	0	0	5	5	PT
6	ME4097	Seminar	0	0	3	1	PT
		Total	12	0	8	18	

ME2111 ESSENTIALS OF MANAGEMENT

Prerequisite: Nil

Total Hours: 42 hours

L	T	P	C
3	0	0	3

Module 1 (9 Hours)

The management process, Schools of management thought, Kinds of managers – basic managerial roles and skills – the nature of managerial work, Contemporary management issues and challenges, Basic elements of planning – types of plans.

Module 2 (9 Hours)

Organizing process, Concepts of authority – responsibility – power – accountability – delegation of authority, Types of organization structures, Directing, Leading – motivational strategies – communication, Basic elements of control.

Module 3 (12 Hours)

Managing human resources in organizations, Functions of financial management – classification of capital – sources of finance – financial statements, Nature of marketing – marketing mix – sales promotion.

Module 4 (12 Hours)

Managerial decision making process – decision criteria under certainty – risk – uncertainty – analytical models of decision making, Network techniques – critical path method – Programme Evaluation and Review Technique – time/cost trade-off in critical path networks.

References

1. Koontz, H., and Weihrich, H., *Essentials of Management: An International Perspective*, 8th ed., McGraw Hill, 2009.
2. Griffin, R.W., *Management: Principles and Applications*, Cengage Learning, 2008.
3. Kotler, P., Keller K.L., Koshy, A., and Jha, M., *Marketing Management*, 13th ed., 2009.
4. Khan, M.Y., and Jain, P.K., *Financial Management*, Tata-McGraw Hill, 2008.

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ME4099 PROJECT

Prerequisite: ME4098 Project

Total Hours: 70

L	T	P	C
0	0	5	5

The project work commenced in VII Semester shall be continued in VIII Semester, normally 5 hours/week. At the end of the VIII semester, the final report/thesis describing the details of the entire project work has to be submitted to the Department, usually in a prescribed format. Presentation of the entire work is to be done before an evaluation committee and a successful oral defense of the thesis before the committee is required.

ME4097 SEMINAR

L	T	P	C
0	0	3	1

Prerequisite: Nil

Total Hours: 42

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

ELECTIVES

ME3021 INTRODUCTION TO FINITE ELEMENT METHODS

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Introduction – various numerical methods – concepts of variational calculus – variational methods of approximation, Ritz method, Weighted residual methods – Galerkin method – subdomain method – least square method – collocation method, Problems.

Module 2 (10 hours)

Finite element analysis of one-dimensional problems – procedure – one-dimensional elements and interpolation functions – analysis of one-dimensional second and fourth order equations – natural co-ordinates – interpolation functions – computer implementation.

Module 3 (12 hours)

Finite element analysis of two-dimensional problems – two-dimensional elements and interpolation functions – second order equations involving a scalar valued function – comments on mesh generation and composition of boundary conditions – analysis of plane elasticity and incompressible fluid flow problems – time dependent problems (transient heat transfer) – iso-parametric elements and numerical integration.

Module 4 (10 hours)

Dynamic Analysis – Hamilton‘s Principle – Eigen value problems – non linear problems – three-dimensional elements and interpolation functions – formulation of three-dimensional problems – two and three-dimensional Navier Stoke‘s equations – three-dimensional heat transfer equations.

References

1. Reddy, J.N., *An Introduction to the Finite Element Method*, 3rd ed.,Tata McGraw-Hill, 2005.
2. Reddy, J.N., *Applied Functional Analysis and Variational Methods in Engineering*, International Edition, McGraw-Hill, 1987.
3. Huebner, K. H., *The Finite Element Method for Engineers*, John Wiley & Sons.
4. Zienkiewicz, O.C., *The Finite Element Method*, Tata McGraw-Hill Edition.
5. Zienkiewicz, O.C., and Morgan, K., *Finite Elements and Approximation*, John Wiley & Sons, 1983.
6. Cook, R.D., Malkus, D.S., Plesha, M.E., and Witt, R.J., *Concepts and Applications of Finite Element Analysis*, 4th ed., John Wiley & Sons, 2004.

ME3022 EXPERIMENTAL STRESS ANALYSIS

Prerequisite: ME2002 Elements of Solid Mechanics or Equivalent

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (9 hours)

Analysis of stress at a point and strain at a point, Stress-strain relations, Principal stresses and principal strains, Prediction of failures,Basic equations in elasticity theory, Formulation of problems, Field equations, Plane stress and plane strain problems, Solution of problems using Airy‘s stress function.

Module 2 (12 hours)

Strain measurements, Strain and its relation to experimental determinations, Types of strain gauges – mechanical strain gauges – optical strain gauges - inductance strain gauges, Electrical resistance strain gauges - strain sensitivity in metallic alloys - gauge construction-strain gauge adhesives and mounting methods - gauge sensitivities and gauge factor – performance characteristics of foil strain gauges - temperature compensation, Strain gauge circuits - potentiometer - Wheatstone bridge circuits.
Strain rosettes- rectangular and delta rosette.

Module 3 (12 hours)

Photo elasticity - basics of optics double refraction - stress optic law - stress and birefringence, Two dimensional photoelasticity - plane polariscope - circular polariscope - isoclinics - isochromatics - effects of stressed model in a plane polariscope and circular polariscope – dark field and light field arrangements, Compensation techniques ,Photoelastic materials, Calibration methods, Separation methods, Scaling model to prototype stresses.

Module 4 (9 hours)

Theory of brittle coating method - coating stresses, Failure theories - brittle coating patterns - crack detection, Ceramic based brittle coatings, Resin based brittle coatings, Test procedures for brittle coating analyses - analysis of brittle coating data.

References

1. James. W. Dally, and William E. Riley, *Experimental Stress Analysis*, McGraw Hill, Third Edn., 1991.
2. R.G. Budynas, *Advanced Strength and Applied Stress Analysis*, McGraw Hill, Second Edn., 1999.
3. L.S. Sreenath, M.R. Raghavan, K. Lingaiah, G. Garghesha, B. Pant, and K. Ramachandra, *Experimental Stress Analysis*, Tata Mc Graw Hill.
4. Timoshenko and Goodier, *Theory of elasticity*, McGraw Hill, New York, Third Edn., 1970.

ME3023 THEORY OF PLASTICITY

Prerequisite: ME2012 Applied Mechanics of Solids

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (10 hours)

Review of the theory of stress and Strain – transformation laws – principal stress and strain – Mohr's circle, Stress strain relations, Material properties, Introduction to the theory of plasticity – behaviour of metals under uni-axial tension and compression — true stress-true strain relations — effect of work hardening, Bollarding and Barrelling, Empirical stress-strain relations for work hardening materials.

Module 2 (10 hours)

Yield criterion – stress space representation of yield criterion – representation of Tresca and von-Mises criterion – yield surface for work hardening materials, Stress strain relations in the plastic range — Prandtl -Reuss, Levy-Mises and St. Venant's stress-strain relations, Plastic potential, Principle of maximum work dissipation.

Module 3 (12 hours)

Elastic-Plastic analysis – pure bending of a beam – torsion of circular bar – thick spherical shell under internal pressure – thick cylindrical shell under internal pressure – rotating cylinders – rotating disks, Plane strain problems – simple slip line fields, Bound theorems and their applications

Module 4 (10 hours)

Application of the theory of plasticity to metal forming operations – plasticity analysis of extrusion and drawing of wires and strips – analysis of tube drawing with mandrels – analysis of rolling – analysis of forging, Load calculations for the operations.

References

1. Chakrabarty, J., *Theory of Plasticity*, Van-Nostrand Reinhold Co., London, 1975.
2. Johnson, W., and Meller, P.B., *Engineering Plasticity*, Mc-Graw Hill Book Co., New York, 1987.
3. Hoffman, O. and Sachs, G., *Introduction to the theory of Plasticity for Engineers*, Mcgraw Hill Book Co., New York, 1953.

ME3024 CONTROL SYSTEMS ENGINEERING

Prerequisite: Nil

L	T	P	C
3	1	0	3

Total Hours: 42

Module 1 (12 hrs)

Introduction to control system engineering, History, Representation of feedback control system by block diagrams, Physical systems and their mathematical models, Representation of linear time invariant systems, Order of the system, Classical method, Transfer function approach, Block diagram reduction, State space representation, Mathematical models of mechanical, electrical, hydraulic and pneumatic elements and systems, Conversion of state Space to transfer function and transfer function to state space, Transformation of mathematical model using MATLAB.

Module 2 (12 hrs)

Transient response analysis, Solution of first order, Second order and Higher order systems, Solution by Laplace transform, Solution of states space equation, Performance parameters of first order and second order systems, Stability of systems, Routh-Hurwitz criterion, Steady state error, Error constants, Improving time response and steady state error, Root locus techniques, Application of MATLAB in transient response.

Module 3 (8 hrs)

Frequency response of systems, Plotting the frequency response, Rectangular plots, Polar plots, Bode plots and Nichols chart, Stability analysis, Nyquist plots and Nyquist criterion, Gain margin, Phase margin, Application of MATLAB in frequency response.

Module 4 (10 hrs)

Design of control systems, The design philosophy, Design of Lead, Lag, Lead- Lag, Proportional, Integral, derivative and PID controllers using Root locus and Bode plot, Tuning of controllers and PID controller gain tuning techniques, Design of controllers via state space, Controllability and observability, Applications of MATLAB in design of controllers.

References

1. Ogata, K., *Modern Control Engineering*, 4th ed., Prentice-Hall of India, 2002.
2. I.J. Nagrath, I.J., and Gopal, M., Control Systems Engineering, 5th ed., New Age International Publishers, 2007.
3. Ogata, K., *System Dynamics*, 4th ed., Pearson Education Inc., 2004.
4. Kuo, B.C., *Automatic Control Systems*, 7th ed., Prentice-Hall of India, 1995.
5. Chen ,C.T., *Linear System Theory and Design*, 3rd ed., Oxford University Press, 1999.
6. Franklin, G.F., Powell, J.D., and Naeini, A.E., *Feedback Control of Dynamic Systems*, 4th ed., Prentice Hall, 2002.
7. Dorf R.C., and Bishop, R.H., *Modern Control Systems*, 11th ed., Pearson Education, 2008.
8. Azzo, J.J.D., and Houpis, C.H., *Linear Control System Analysis and Design*, 4th ed., McGraw Gill Publishers, 1995.

ME3025 NONLINEAR DYNAMICS AND CHAOS

Prerequisite: ZZ1001 Engineering Mechanics

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Introduction to dynamical systems, Discrete and continuous time systems, Autonomous and non-autonomous systems, Discrete time systems – one-dimensional map – fixed points of maps and their stability, Bifurcation of maps, Continuous time systems – phase space and flows – attracting sets, Concepts of stability.

Module 2 (10 hours)

Equilibrium solutions, Fixed points and stability of continuous time systems, Classification and stability of equilibrium solutions, Periodic solutions – Periodic solutions of continuous time dynamical systems, Autonomous and non-autonomous systems, Limit cycle, Poincaré section, Bifurcation – local and global bifurcation of continuous systems – static and dynamic bifurcations – Hopf bifurcations, Quasiperiodic solutions, Circle map.

Module 3 (10 hours)

Dynamics of discrete time systems, Logistic equation – bifurcation diagram of one-dimensional maps – chaotic solutions of maps, Henon map, Continuous systems – Duffing's equation – Rossler equations- period doubling and Intermittency mechanisms, Tools to identify and analyze motions – time history – state-space and pseudo state space- Fourier spectra – Poincare' sections and maps, Lyapunov exponents.

Module 4 (12 hours)

Fractals and dynamical systems, Examples of fractals – Koch curve – Cantor set etc., Fractal dimension – measures of fractal dimension, Computational methods – shooting method, harmonic balance method, Determination of Lyapunov exponents and fractal dimensions, Applications of nonlinear dynamics.

References

1. Strogatz, S.H., *Nonlinear Dynamics and Chaos*, Westview Press, 1994.
2. Nayfeh, A.H., and Balachandran, B., *Applied Nonlinear Dynamics*, John Wiley & Sons, 1995.
3. Thomson, J.M.T., and. Stewart, H.B, *Nonlinear Dynamics and Chaos*, John Wiley & Sons, 1986.
4. Moon, F.C., *Chaotic and Fractal Dynamics*, John Wiley & Sons, 1987.
5. Baker, G.L., and Gollub, J.P., *Chaotic Dynamics*, 2nd ed., Cambridge University Press, 1996.
6. Peitgens, Jurgens, and Saupe, *Chaos and Fractals*, Springer Verlag, 1992.
7. Scheinerman, E.R., *Invitation to Dynamical Systems*, Prentice hall, New Jersey, 1996.
8. Drazin, P.G., *Nonlinear Systems*, Cambridge University Press, 1992.
9. Devaney, R.L., *An Introduction to Chaotic Dynamical Systems*, 2nd ed., Addison-Wesley, 1989.
10. Jordan, D.W., Smith, P, *Nonlinear ordinary differential equations*, 4th ed., Oxford University Press, 2007.

ME3026 ENGINEERING FRACTURE MECHANICS

Prerequisite 1: ME2002 Elements of Solid Mechanics

Prerequisite 2: ME2012 Applied Mechanics of Solids/

ME2015 Theory of Elasticity and Plasticity

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (10 hours)

Introduction – significance of fracture mechanics, Stress concentration factor, Griffith energy balance approach, Irwin's modification to the Griffith theory, Stress intensity approach, Crack tip plasticity, Fracture toughness, Subcritical crack growth, Influence of material behaviour, Problems in I, II & III modes, Mixed mode problems, Linear elastic fracture mechanics (LEFM) – elastic stress field approach – mode I elastic stress field equations – expressions for stresses and strains in the crack tip region, Finite specimen width, Superposition of stress intensity factors (SIF), SIF solutions for well known problems.

Module 2 (10 hours)

Energy balance approach – Griffith energy balance approach – relations for practical use, Determination of SIF from compliance, Slow stable crack growth and R-curve concept, Description of crack resistance, LEFM Testing – Plane strain and plane stress fracture toughness testing, Determination of R-curves, Effects of yield strength and specimen thickness on fracture toughness, Practical use of fracture toughness and R-curve data.

Module 3 (10 hours)

Crack Tip Plasticity – Irwin plastic zone size – Dugdale approach – shape of plastic zone – state of stress in the crack tip region, Elastic plastic fracture mechanics (EPFM) – development of EPFM, J-integral, Crack opening displacement (COD) approach, COD design curve, Relation between J and COD, Standard J_{IC} test and COD test. **Module 4 (12 hours)**

Fatigue crack growth – description of fatigue crack growth using stress intensity factor, Effects of stress ratio and crack tip plasticity, Crack closure, Paris Law, Prediction of fatigue crack growth under constant amplitude and variable amplitude loading, Fatigue crack growth from notches – short crack problem, Practical problems – through cracks emanating from holes – corner cracks at holes – cracks approaching holes – fracture toughness of weldments – service failure analysis – applications in pressure vessels, pipelines and stiffened sheet structures.

References

1. Ewalds, H.L. and Wanhill, R.J.H., *Fracture Mechanics*, 1st ed., Edward Arnold Edition, 1993.
2. Broek, D., *Elementary Engineering Fracture Mechanics*, 4th ed., Sijthoff & Noordhoff International Publishers, 1991.
3. Kåre Hellan, *Introduction to Fracture Mechanics*, McGraw-Hill Book Company, 1983.
4. Prashant Kumar, *Elements of Fracture Mechanics*, Wheeler Publishing, 1999.

ME3027 FLUID POWER CONTROLS

Prerequisite: ME2001 Fluid Mechanics

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (10 Hours)

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

Module 2 (11 Hours)

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

Module 3 (11 Hours)

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

Module 4 (10 Hours)

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

References

1. Joji,P., Pnumatic controls, Wiley India Pvt. Ltd., 2008.
2. Anthony Esposito., Fluid Power with applications, Pearson Education.
3. Ernst, W., Oil Hydraulic Power and its Industrial Applications, New York, McGraw Hill.
4. Lewis, E. E., and H. Stern, Design of Hydraulic Control Systems, New York, McGraw Hill.
5. Morse, A. C., Electro hydraulic Servomechanism, New York, McGraw Hill.
6. Pippenger, J.J., and R.M. Koff, Fluid Power Control systems, New York, McGraw Hill.
7. Fitch, Jr., E.C., Fluid Power Control Systems, New York, McGraw Hill.
8. Khaimovitch., Hydraulic and Pneumatic Control of Machine Tools.
9. John Watton., Fluid Power Systems: modeling, simulation and microcomputer control, Prentice Hall Int.
10. Herbert E. Merritt., Hydraulic control systems, John Wilely and Sons Inc.
11. Thoma, Jean U., Hydrostatic Power Transmission, Trade and Technical Press, Surrey, England.
12. Ian Mencal., Hydraulic operation and control of Machine tools, Ronald Press.
13. Sterwart., Hydraulic and Pneumatic power for production, Industrial Press.
14. Hasebrink J.P., and Kobler R., Fundamentals of Pnuematics/electropeumatics, FESTO Didactic publication.
15. Werner Deppert and Kurt Stoll., Pneumatic Control-An introduction to the principles, Vogel – Verlag.
16. Blaine W. Andersen., The analysis and Design of Pneumatic Systems, John Wiley and Sons, Inc.
17. Blackburn, J.F., G. Reethof, and J.L. Shearer, Fluid Power Control, New York, Technology Press of M. I. T.

ME3028 ADVANCED THERMODYNAMICS

Prerequisite: ME2014 Thermodynamics

L	T	P	C
3	1	0	3

Total Hours: 42

Module 1 (10 hours)

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

Module 2 (10 hours)

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

Module 3 (10 hours)

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

Module 4 (12 hours)

Critical phenomena, Liquid and solid Helium, Nernst postulate, Introduction to irreversible thermodynamics linearised relation Onsager‘s reciprocity theorems, Special topics on advanced thermodynamics.

References

1. Callen, H.B., *Thermodynamics and an Introduction to Thermostatics*, Second Edition, John Wiley & Sons, 1985.
2. Rao, Y.V.C., *Postulational and Statistical Thermodynamics*, Allied Publishers, 1994.
3. Zemansky, M.W., Abbot, M.M. and Van Ness, H.C., *Basic Engineering Thermodynamics*, McGraw-Hill, 1987
4. Saad, M.A., *Thermodynamics for Engineers*, Prentice Hall of India, 1987.
5. Lee, J.F., Sears, F.W., *Thermodynamics: An Introductory Text for Engineering Students*, Addison Wesley, 1964.
6. Wark Jr., K., *Advanced Thermodynamics for Engineers*, McGraw-Hill, 1995.
7. O‘ Cornell, J. P. and Maile, J. M., *Thermodynamics – Fundamentals for Applications*, Cambridge University Press, 2004.
8. Sonntag, R.E., Borgnakke, C and Van Wylen, G. J., *Fundamentals of Thermodynamics*, Sixth Edition, John Wiley & Sons, 2004.

ME3029 COMPUTATIONAL METHODS IN ENGINEERING

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (8 hours)

Basic consideration in numerical methods, Numerical error and accuracy – round-off error – truncation error – accuracy of numerical results – Numerical stability, Iterative convergence – conditions of convergence – rate of convergence – termination of iteration, Numerical parameters – step size – convergence criterion, Numerical differentiation, – Taylor series approach – polynomial fitting approach.

Module 2 (12 hours)

Numerical solution of linear algebraic equations, Direct methods – Gaussian elimination – tridiagonal matrix algorithm – LU decomposition, Indirect methods – Jacobi iteration – Gauss-Seidel iteration, Under relaxation and over relaxation, Root of equations, Search method for real roots, Bisection method, Regula falsi and secant methods, Newton-Raphson method and modified Newton‘s method .

Module 3 (10 hours)

Numerical curve fitting and interpolation, Exact fit and interpolation – exact fit with an n-th order polynomial – uniformly spaced independent variable, Lagrange interpolation, Newton‘s divided-difference interpolating polynomial – general formulas – uniformly spaced data – extrapolation, Numerical interpolation with splines, Method of least squares for a best fit –basic considerations – linear regression – best fit with a polynomial.

Module 4 (12 hours)

Numerical integration – rectangular and trapezoidal rules – Simpson‘s rules, Higher-accuracy methods – Richardson extrapolation – Romberg integration – higher-order Newton-Cotes formulas , Integration with segments of unequal width – unequally space data – adaptive quadrature – Gauss quadrature, Numerical solution of ordinary differential equations, Initial value problems – Euler‘s method – Heun‘s method – Modified Euler‘s method – Runge-Kutta methods – predictor-corrector methods, Boundary value problems – shooting methods – finite difference methods.

References

1. Jaluria, Y., *Computer Methods for Engineering*, Allyn and Bacon, Inc., 1988.
2. Chapra, S.C., and Canale, R.P., *Numerical Methods for Engineers,* 4th ed, Tata McGraw-Hill, 2002.
3. Griffith, D.V., and Smith, I.M., *Numerical Methods for Engineers:A Programming Approach*, CRC Press, 1991.

ME3121 POWDER METALLURGY

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Versatility and benefits of Powder Metallurgy, PM Process, Powder production techniques - mechanical, atomisation, chemical - reduction and carbonyl and electro-chemical processes: Ceramic powder production, Powder properties and their characteristics, Sieve analysis, Microscopy, Sedimentation analysis: Specific surface and other technological properties: Powder conditioning.

Module 2 (11 hours)

Compaction and shaping - Cold and Iso-static compaction, Die compaction, Pressing equipments and tooling: Powder Injection Moulding, Extrusion and rolling. Hot compaction techniques, Hot Iso-static Pressing (HIP), equipments, tooling and applications: Explosive compaction: Slip casting.

Module 3 (10 hours)

Sintering - stages, single component, material transport mechanisms: Model studies: Powder shrinkage experiments: Sintering diagrams and sintering anomalies. Multi-component sintering - solid phase and liquid phase, infiltration and reaction sintering: Sintering atmospheres and equipments.

Module 4 (11 hours)

Powder metallurgy products, Porous parts, Sintered carbides, Cermets, Electric and magnetic parts and ceramic components, Sintered friction materials. P/M parts of the year, Research trends in Powder Metallurgy.

References

1. Thummler, F., and Oberacker, R., *An introduction to Powder Metallurgy*, The Institute of Materials, The University Press, Cambridge Great Britain.
2. ASM Handbook, *Powder Metal Technologies and Applications* (ASM Handbook, Vol 7).
3. Leander, F., and West, W.G., *Fundamentals of Powder Metallurgy*, Metal Powder Industries Federation, 2002.
4. Upadhyaya, G.S., *Powder Metallurgy Technology*, 1st ed., Cambridge International Science Publishing Co, 2002.
5. Sinha, A.K., *Powder Metallurgy*, Dhanpat Rai Publications, 2003.
6. Angelo, P.C., and Subramanian, R., *Powder Metallurgy*, Prentice Hall of India, 2008.

ME3122 INTRODUCTION TO MARKETING

Prerequisite: MA2001 Mathematics III: Probability and Statistics

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1(10 Hours)

Introduction to marketing, Evolution of marketing concept, Scope of marketing, Marketing management task, Functions of marketing, Marketing mix, Developing marketing strategies, Marketing and customer value, Corporate and division. Strategic planning in marketing, Business unit strategic planning, Contents of marketing plan.

Module 2 (10 Hours)

Identifying market segments and targets, Levels of market segmentation, Base for segmenting consumer markets, Base for segmenting business markets, Marketing Research--Marketing Research Process-Research objectives, Research Plan development, Collecting information, Analysis.

Module 3 (10 Hours)

Analyzing consumer markets, Influencing consumer behavior, The buying decision process, Theories of consumer decision making, Analyzing Competitive strategies business markets, Organizational buying, Participating in the buying process, Stages in buying process, Managing business to business customer relations, Institutional government markets.

Module 4 (12 Hours)

Product strategy, Product characterization and classification, Product and brand relationship, Packaging, Challenges in new product development, Consumer adoption process, Product lifecycle marketing strategy, Brand management, Developing pricing strategies and progress, Understanding prices, Setting the prices, Adapting the prices, Initiating and responding to price changes.

References

1. Kotler, P., Keller, K..L., Koshy, A., and Jha, M., *Marketing Management*, 13th edition, Prentice Hall India Ltd, New Delhi, 2009.
2. Ramaswamy V.S and Namkumari S., *Marketing Management,* Macmillan India Ltd, New Delhi, 1997.
3. Keegan, *Global Marketing Management,* Pearson Education India, New Delhi, 2002.
4. Saxena, *Marketing Management,* 2nd edition, Tata McGraw Hill , 2002.

ME3123 DESIGN AND ANALYSIS OF MANAGEMENT INFORMATION SYSTEMS

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (11 hours)

Concepts of data and information – Producing information from data – economies of information – analysis of system – management and formal information system concepts, Building blocks in information systems – system design forces – information development life cycle – information systems for strategic planning.

Module 2 (10 hours)

General steps in Information system design – systems investigation and requirements engineering – System analysis and general system design – charting tools for system analysis and design.

Module 3 (11 hours)

Introduction to database management – classification of data items – Coding considerations – types of code structures – Forms design. General File storage consideration – composition and classification of data files – selection consideration for file media and file organization methods, concepts of data structures – data association – sorting and searching techniques.

Module 4 (10 hours)

System implementation – Verification and Validation of Software system – Software metric and models, introduction to capability maturity model – software testing approaches – training and post implementation audit – Recent developments in information systems, Security features in global information systems.

References

1. Burch and Grudnitski, *Information Systems – Theory and Practice*, 5th ed., John Wiley & Sons, New York, 1989.
2. Hawryszkiewycz, I.T., *Introduction to Systems Analysis and Design*, Prentice Hall of India, 1989.
3. Ian Sommerville, *Software Engineering*, 6th ed., Pearson Education Asia, 2001.
4. Lucas, Henry C., *Analysis, Design, and Implementation of Information Systems*, 4th ed., McGraw Hill, New York, 1992.
5. O' Brien, J.A., *Management Information Systems*, 4th ed., Tata McGraw Hill, 1999.

ME3124 WORK DESIGN AND MEASUREMENT

Prerequisite: Nil

Total Hours: 42 hours

L	T	P	C
3	0	0	3

Module 1 (12 Hours)

Definition and scope of work design and measurement – work Design and methods study – scope of work design – procedure for methods study – process analysis – process charts – operation analysis – cyclographs – principles of motion economy, Work Measurement – objectives – time study equipment – establishment and maintenance of time standards, Allowances and performance rating, Concept of rating in time study.

Module 2 (10 Hours)

Precision time measurement, Synthesis of standard data, Pre-determined fundamental motion time standards – MTM, Work factor System, Standard data, Work sampling – statistical techniques in work sampling – confidence limits, Work Study in office – work simplification – measurement of performance, Forms design – diagnostic and procedure charts.

Module 3 (10 Hours)

Ergonomics –nature of man-machine systems – characteristics – purpose, Operational functions and components – types of systems, Information input and processing, Sources and pathways of stimuli, Human information processing, Visual displays – quantitative and qualitative displays – visual codes, symbols and signs – general guidelines in design of visual displays.

Module 4 (10 Hours)

Auditory and tactual displays – masking – types of auditory displays – cutaneous senses , Tactual displays, Speech communication – speech intelligibility – components of speech communication, Nature of human activity and their effects, Bases of human motor activity – human control of systems – input-output channels – compatibility, Influence of display factors and control factors on system control.

References

1. Barnes, R. M, *Motion and Time Study: Design and Measurement of Work*, John Wiley & Sons, NY, 7th ed., 1980.
2. Mark S. Sanders and Earnest J. McCormick, *Human Factors in Engineering and Design*, 6th ed., McGraw-Hill, 1987.
3. Marvine E., Mundel, D. Danner, and David L.Anner, *Motion and Time Study*, 6th ed., Prentice Hall of India, 1985.
4. Murrell K.F.H. and Schnauber, H, *Ergonomics*. Econ, Munich, 1986.
5. Gavriel Salvendy, *Handbook of Human Factors & Ergonomics*, Inter-science, 1997.

ME3125 COST ANALYSIS AND CONTROL

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1(10 Hours)

Nature of Management Accounting, Generally accepted Accounting Principles and Accounting Standards, Accounting Cycle and Statements of Financial Information Understanding Corporate Financial Statements and Reports.

Module 2 (10 Hours)

Cash Flow Statement, Financial Statements Analysis, Cost Concepts and Management Needs, Costing and Control of Materials, Costing and Control of Labour ,Costing and Control of Factory (Manufacturing) Overheads ,Costing and Control of Administrative, Selling and Distribution Overheads.

Module 3 (10 Hours)

Activity Based Costing System, Job-Order and Batch Costing, Process, Joint and By-Product Costing, Variable Costing and Absorption (Full) Costing

Module 4 (12 Hours)

Volume-Cost-Profit Analysis, Budgeting and Profit Planning, Standard Costs and quality Costs, Cost Variance Analysis, Revenue and Profit Variance Analysis, Responsibility Accounting, Short-Run Decision Analysis, Capital Budgeting

References

1. Khan, M Y. and Jain, P K, *Management Accounting: Text, Problems and Cases, 4/e,* Tata McGraw-Hill, 2009.
2. Horngren, C.T., Datar, S.T., Foster, D., Rajan, M.V. and Ittner, C., *Cost Accounting: Managerial Emphasis*, 13th ed., Pearson, 2009.
3. Khan, M Y. and Jain, P K, *Cost Accounting and Financial Management,* Tata McGraw-Hill, 2008.

ME3126 SUPPLY CHAIN MANAGEMENT

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Introduction and a strategic view of supply chains, Evolution of Supply Chain Management (SCM), Importance of the supply chain, Decision phases in a supply chain, Process views of supply chain, Enablers of supply chain performance, Supply chain performance in India – challenges in maintaining supply chain in India, Supply chain strategy and performance measures– competitive and supply chain strategies – customer service and cost trade –offs, Achieving strategic fit, Supply chain performance measures – enhancing supply chain performance.

Module 2 (11 hours)

Supply chain drivers – framework for structuring drivers, Introduction to inventory management – types of inventory – inventory related costs, Managing inventories in a supply chain – single stage inventory control, Inventory control policies – periodic review and continuous review – deterministic and probabilistic models – managing cycle stock, safety stock and seasonal stock, Impact of service level on safety stock, Analyzing impact of supply chain redesign on the inventory – impact of centralization and decentralization on inventory – choice of mode of transport.

Module 3 (11 hours)

Drivers of transportation decisions – modes of transportation– choices and comparison of their performance measures, Devising a strategy for transportation – distribution network design options for a transportation network – cross docking practices, Vehicle scheduling in transportation – savings algorithm, Network design and operation decisions – role of network design in the supply chain – factors influencing network design decisions – framework for network design decisions.

Module 4 (10 hours)

Models for facility location and capacity allocation – network optimization models – capacitated plant location models – gravity location models – network operations model, Strategic role of units in the network, Innovations in supply chains– supply chain integration – internal and external, Bullwhip effect – quantifying the bullwhip effect, Remedial strategies for coping with the bullwhip effect, Supply chain restructuring– postponement – supply chain mapping – move from make to stock (MTS) to customer to order (CTO) model, Enabling supply chain management through information technology .

References

1. Shah, J., *Supply Chain Management –Text and Cases*, Pearson Education, 2009.
2. Chopra, S., and Meindel, P., *Supply Chain Management: Strategy, Planning, and Operation*, Pearson Prentice Hall of India, 2007.
3. Levi, D.S., Kaminsky, P., Levi, E.S., and Shankar, R., *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies*, Tata McGraw Hill, 2008.
4. Chase, R.B., Shankar, R., Jacobs, F.R., and Aquilano, N.J., *Operation and Supply Chain Management*, Tata McGraw Hill, 2010.
5. Shapiro, J.F., *Modeling the Supply Chain*, Thomson Learning, 2007.
6. Vollmann, T.E., Berry, W.L., Whybark, D.C., and Jacobs, F.R., *Manufacturing Planning and Control for Supply Chain Management*, Tata McGraw–Hill, 2006.

ME3127 MANAGEMENT OF ORGANISATIONAL BEHAVIOUR

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (11 Hours)

Introduction to Organizational Behaviour (OB): - Development and challenges, assumptions of contemporary OB. Foundations of individual behaviour values – attitudes – personality – emotions – perception – abilities – motivation in organisations – work related attitudes.

Module 2 (11 Hours)

Group Process: Foundations of group behavior, understanding team, communication, leadership, power, conflict and negotiation.

Module 3 (10 Hours)

Organisational Process: Work design and technology, organisation structure and design – organisational culture.

Module 4 (10 Hours)

Special topics: Organisational change, stress management, decision making in organisations.

References

1. Robbins, *Organisational Behavior*, 9th ed., Pearson Education, 2002.
2. Greenberg and Baron, *Behavior in Organisations*, 7th ed., Pearson Education, 2002.
3. Machane and Vonglinow, *Organisational Behavior*, 2nd ed., TMH, 2003.
4. Hersey, Balaschard and Johnson, *Management of Organisational Behavior*, 8th ed., Pearson Education, 2002.

ME3128 PRODUCTION PLANNING AND CONTROL

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (12 Hours)

Evolution of manufacturing planning and control (MPC) system – MPC system framework, Continuous improvement, Process reengineering, Just-in-time principles – various kind and sources of waste in manufacturing operations, Forecasting – forecasting for established and new product – time series analysis – error measurement.

Module 2 (10 Hours)

Sales and operations planning – sales and operations planning process – strategic variables – relevant cost – quantitative methods, Master production scheduling (MPS) – MPS technique – final assembly schedule – freezing and time fencing.

Module 3 (10 Hours)

Material requirements planning (MRP) – advanced concepts in MRP – lot sizing – buffering concept – nervousness, Just-in-time (JIT) – advanced concepts in JIT – pull production systems, Mixed model production schedule.

Module 4 (10 Hours)

Shop-floor control and capacity analysis – hierarchy of capacity planning decisions – capacity planning and control techniques – input/output control – frame work of shop-floor control – production activity control techniques – advanced concepts in scheduling.

References

1. Vollmann, Berry, Whybark and Jacobs, *Manufacturing Planning and Control for Supply Chain Management*, 5th ed., Tata McGraw-Hill Edition, 2005.
2. Nicholas, J.M., *Competitive Manufacturing Management: Continuous Improvement, Lean production and Customer – Focussed Quality*, Tata McGraw Hill Edition, 2001.
3. Narasimhan, S.L., McLeavy, D.W., and Billington, P.J., *Production planning and Inventory Control*, 2nd ed., Prentice-Hall of India, 2000.
4. Tersine, R.J., *Production and Operations Management: Concepts, Structure, and Analysis*, 2nd ed., North-Holland, 1985.
5. Monks, J.G., *Operations Management: Theory and Problems*, 3rd ed., McGraw-Hill International Edition, 1987.
6. Panneerselvam, R., *Production and Operations Management*, Prentice-Hall of India, 2001.

ME3129 MANAGEMENT OF HUMAN RESOURCES

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (11 Hours)

Human Resource Management - Historical Evolution, Topology of companies, concept of an involved employee, HR issues, Corporate and HR strategy - Linking Business and HR planning - HR instruments- Diversity issues.

Module 2 (11 Hours)

Personnel Management: Personnel Functions – Personnel Management Environment in India – Manpower Planning - Recruitment – selection and Induction of Employees – Staff Training and Development – Career Planning – Job Analysis and Design – Compensation Planning – Salary Administration – Job Evaluation – Merit Rating – Incentive Schemes.

Module 3 (10 Hours)

Industrial Relations: Managing Industrial Relations – Labour Laws – Trade Union – Employee Discipline – Grievance handling mechanisms – Suspension, Dismissal and Retrenchment – Industrial Conflict Resolution – Collective Bargaining – Productivity Bargaining – Workers, Participation in Management – Gold Collar Employee Management – Recent issues in Industrial Relations – Turnover.

Module 4 (10 Hours)

Organizational Development: Organizational Design – Dimensions – Restructuring Strategies – Work Organization – Organizational Development – Change Agents – Process of organizational change – Managing Resistance to Change – Modules in OD – Role of Counseling.

References

1. Dwivedi, R.S., *Manpower Management – An Integrated Approach to Personnel Management and Labour Relations*, PHI, 1984.
2. Yoder, D., and Staodohar P.D., *Personnel Management and Industrial Relations*, PHI 1986.
3. Monappa, A., and Saiyadain M. S., *Personnel Management*, TMH, 1988.
4. Kapoor, N.D., *Introduction to Commercial and Industrial Law*, Sultan Chand & Sons, New Delhi, 1986.

ME3130 QUALITY PLANNING AND ANALYSIS

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Introduction – history, definition, Responsibility for quality, Total quality management – approach, Leadership, Customer satisfaction, Employee involvement, Continuous process improvement, Supplier partnership, Cost of poor quality.

Module 2 (12 hours)

Seven QC tools, Quality function deployment, ISO 9000, Bench marking, Poka yoke, Failure mode and effect analysis, Design of experiments, Taguchi's quality engineering, Total productive maintenance.

Module 3 (10 hours)

Statistical quality control – fundamentals – assignable causes, Rational subgrouping, Control charts for variables – average range chart, average standard deviation chart, control charts for attributes – chart for fraction non-conforming, chart for count of non-conformities, Process capability, Six sigma.

Module 4 (10 hours)

Acceptance sampling – operating characteristic curve, Types of sampling plans, Acceptance quality level, Average outgoing quality, Sampling plan design, Reliability – life-history curve, System reliability, Testing.

References

1. Besterfield, D.H., *Quality Control*, 7th ed., Pearson Education, 2006.
2. Juran, J. M. and Gryna, F. M., *Quality Planning and Analysis*, 3rd ed., Tata McGraw Hill, 1995.
3. Grant, E.L. and Leavenworth, R.S., *Statistical Quality Control*, 7th ed., Tata McGraw-Hill, 2000.

ME4021 INDUSTRIAL TRIBOLOGY

Prerequisite 1: ME2001 Fluid Mechanics/ ME2004 Fluid Mechanics and Machinery

Prerequisite 2: ME2012 Applied Mechanics of Solids/

ME2015 Theory of Elasticity and Plasticity

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 hours)

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

Module 2 (11 hours)

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

Module 3 (10 hours)

Costs of wear, Surface topography, Mechanics of contact, Theories of friction, Friction of metals and non-metals, Temperature of sliding surfaces, Stick-slip, Rolling friction.

Module 4 (10 hours)

Wear of metals, Adhesive wear, Abrasive wear, Corrosion and corrosion wear, Erosion, Surface fatigue and impact wear, Wear of elastomers, Wear of ceramics and composite materials, Measurement of friction and wear.

References

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

ME4022 VEHICLE DYNAMICS

Prerequisite: ME2003 Engineering Mechanics – Dynamics
Total hours: 42

L	T	P	C
3	0	0	3

Module 1 (11 Hours)

Introduction to vehicle dynamics, Acceleration performance, Braking performance, Aerodynamics and rolling resistance, Steady-state cornering, Suspensions – steering systems, Rollover-acceleration – braking and turning forces.

Module 2 (11 Hours)

Front wheel geometry–effects of front wheel geometry on vehicle performance, Dynamic axle Loads, Transient rollover, Acceleration–Traction limited acceleration–Power limited acceleration–Road friction, Rear wheel lockup, Drag forces, Total road loads, Vibration, Roll center analysis.

Module 3 (10 Hours)

Tyre construction –Types- Types of tyers–Basic Tyre modelling considerations–Tyre forces on hard surfaces–Tyre-soil interaction, Characterizing typical terrains for mobility analysis.

Module 4 (10 Hours)

Sensors, Actuators, Cruise control, Antilock braking system (ABS), Traction control, Directional control, Vehicle stability controls, Active suspension, Computer aided analysis/Simulation–Simulation with MATLAB-Simulink and ADAMS.

References

1. Thomas D. Gillespie, *Fundamentals of Vehicle Dynamics*, Society of Automotive Engineers, 1992.
2. Wong, J.Y., *Theory of Ground Vehicles*, John Wiley and Sons, 3rd ed., 2001.
3. Hans Pacejka, *Tyre and Vehicle Dynamics*, SAE Publications, 2nd ed., 2005.
4. Blundell, M. and Harty, D., *The Multi body Systems Approach to Vehicle Dynamics*, Elsevier Publications, 2004.

ME4023 INTRODUCTION TO ROBOTICS

Prerequisite: Nil

L	T	P	C
3	1	0	3

Total Hours: 42

Module 1 (11 hrs)

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

Module 2 (10 hrs)

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

Module 3 (11 hrs)

Linear and rotational velocity of rigid bodies, Velocity propagation from link to link, Jacobians, Singularities, Static forces in manipulators, Jacobians in force domain, Cartesian transformation of velocities and static forces. Forward and Inverse Dynamics, Lagrangian and Newton – Euler‘s formulation methods, Examples.

Module 4 (10 hrs)

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

References

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

ME4024 DESIGN FOR MANUFACTURABILITY

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (9 hours)

Introduction – Design philosophy, implementing DFM, Benefits of DFM Concurrent Engineering – Design for quality, Design for Life Cycle, Design for Cost, Enabling Technology, Concurrent Engineering and the Organization, Improving the Development process. Management Frameworks – Architecture, Management's concerns with Manufacturability, Team Building and Training. Team Building and Training - Justification of DFM, Viewpoints for DFM.

Module 2 (9 hours)

Quality Tools in DFM – Problem Solving Tools, Quality Function Deployment, Benchmarking, Computer Improvement, Taguchi approach. Computer Aided Technology – CAD/CAM/CAE, Rapid Prototyping, Group Technology, CIM Creative Thinking in DFM, Tools. General Product Design – Impact of Design concept and early project decisions, Evaluating manufacturability of conceptual designs, Producibility, Geometric Tolerancing.

Module 3 (12 hours)

Design for Assembly – Principles, improving serviceability, recyclability. Design for Machining – Principles, Non-Traditional Machining. Design for forming – Principles, fine blanking, roll forming, precision forming, metal spinning, tube fabrication.

Module 4 (12 hours)

Design for Forging, Casting. Design for Coating – Painting, powder coating, metal spraying. Design for Heat Treatment. Design for Fastening & Joining – Design guidelines for fasteners, adhesive assembly, and welded assemblies. Design for Materials: Plastics, Composites, Ceramics, Powder Metallurgy.

References

1. Chitale, A.K., and Gupta, R.C., *Product Design and Manufacturing*, Prentice-Hall Of India Pvt. Ltd, 2004.
2. Dieter, G.E., and Schmidt, L.C., Engineering Design: A Materials And Processing Approach, 4th ed., McGraw Hill, 2009.
3. Bakerjian, Ramon, Ed., *Design for Manufacturability*, Tool & Manufacturing Engineers Handbook, Society of Manufacturing Engineers, 1992.

ME4025 MECHATRONICS

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (10 Hrs)

Introduction to mechatronics Systems, Key elements, Mechatronics design process, Types of design – Traditional and mechatronics designs, Information systems, Real time interfacing (Hardware-in-the loop simulation), Elements of data acquisition system.

Module 2 (11 Hrs)

Introduction to actuators, sensors and transducers, Mechanical, fluid power and electrical actuators, Actuator selection criteria, Performance characteristics of sensors, Sensors for position, motion, force and temperature, Flow sensors, Range sensors, Ultrasonic sensors, Fibre optic sensors, Selection of sensors. Special transducers - Piezoelectric transducer - Magnetostrictive transducer - Shape memory alloy (SMA) transducer.

Module 3 (11 Hrs)

Introduction to signals, system and controls, System representation, Linearisation, Time delays, Measures of system performance, Closed loop controllers – PID controller – Digital controllers, Controller tuning, Adaptive control, Supervisory control, Introduction to microprocessors, Microcontrollers and programmable logic controllers, Components, PLC programming.

Module 4 (10 Hrs)

Introduction to MEMS, Microsensors in mechatronics, Sensors for condition monitoring, Artificial intelligence in mechatronics, Introduction to fuzzy logic control and neural networks, Case studies of mechatronics systems.

References

1. Bolton, W., *Mechatronics*, Pearson Education Asia, 2004.
2. Shetty, D., and Kolk, R.A., *Mechatronics System Design*, Thomson Learning, 2001
3. Necsulescu, D., *Mechatronics*, Parson Education Asia, 2002.
4. H.M.T. Ltd, *Mechatronics*, Tata McGraw Hill Publishers, 1998.
5. Singh, B.P., *Microprocessors and Microcontrollers*, Galgotia Publishers, 1997.
6. Petruzella, F.D., *Programmable Logic Controllers*, Tata McGraw Hill Publishers, 1989.
7. Kant, K., *Computer Based Industrial Control*, Prentice Hall India, 1999.

ME4026 UNCONVENTIONAL ENERGY SYSTEMS

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (12 hours)

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

Module 2 (10 hours)

Biomass energy systems – biomass conversion routes – combustion – gasification – anaerobic digestion – pyrolysis – cogeneration, Performance analysis and testing, Thermal applications – power generation.

Module 3 (10 hours)

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

Module 4 (10 hours)

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

References

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

ME4027 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total Hours: 42

Module 1 (10 hours)

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

Module 2 (10 hours)

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

Module 3 (10 hours)

Computational Methods for one, two and three-dimensional heat equations - explicit, implicit, Crank-Nicholson, ADI schemes, ADE schemes, Fractional step methods, Hopscotch scheme, Douglass scheme, Conservative form of partial differential and finite difference equations, Methods to deal interface property and non linearity, Consistency, stability and convergence of computational methods, Discrete perturbation stability analysis, Von-Neumann stability analysis, Validation of computational solution.

Module 4 (12 hours)

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

References

1. Anderson, D.A., Tennehill J.C., and Pletecher R.H., *Computational Fluid Mechanics and Heat Transfer*, Hemisphere, 1984.

8. Patankar, S.V. *Numerical Heat Transfer and Fluid Flow*, Hemisphere, 1980.
9. Muraleedhar, K., and Sundararajan, T. *Computational Fluid Flow & Heat Transfer*, Narosa, 1995.

10. Versteeg, H.K. & Malalasekera, W. *An introduction to computational fluid Dynamics*: *The Finite Volume Method*, Adison Wesley-Longman, 1995.

11. Roache, P.J. *Computational Fluid Dynamics*, 2edn, Hermosa, 1982.
12. Hornbeck, R.W. *Numerical Marching Techniques for Fluid Flows with Heat Transfer NASA*, SP-297, 1973.

13. Hoffmann Klaus. A., *Computational Fluid Dynamics for Engineers-Volume I*, Engineering Education System, Wichita, 1993.

ME4028 AERODYNAMICS

Prerequisite: ME2001 Fluid Mechanics

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 hours)

Equations for incompressible inviscid flows, Fluid circulation and rotation – vorticity - Kelvin‘s theorem - velocity potential - stream function - equation of a stream line - complex potential, Blasius theorem for force and moment on bodies, Elementary flow patterns and their superposition.

Module 2 (11 hours)

Flow past a cylinder - Magnus effect - Kutta condition - Vortex theory of lift. Conformal transformation, The Joukowski transformation - lift on arbitrary cylinder, Aerodynamic center, Pitching moment.

Module 3 (10 hours)

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

Module 4 (10 hours)

Finite wings - downwash and induced drag - Prandtl-Lachester theory - Biot- Savart law, General series solution, Glauret method, Multhop‘s method, Horseshoe effects, Ground effects, Lineraised compressible flows in two dimensions - flow past a wavy wall, Similarity rules, Aerofoil in compressible flows.

References

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

ME4029 HEATING, VENTILATION AND AIR CONDITIONING

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 Hours)

Principles of refrigeration -- Carnot refrigeration cycle -- unit of refrigeration – capacity -- coefficient of performance.

Refrigeration systems -- vapour compression system – theoretical and practical cycles – system components – compressors – condensers – expansion devices – evaporators – refrigerants.

Air refrigeration cycle, Vapour absorption refrigeration system.

Module 2 (11 Hours)

Psychrometry – psychrometric processes – determination of condition of air entering conditioned space.

Air conditioning systems – summer, winter and year-round-year air conditioning systems -- central and unitary systems.

Requirement of air conditioning – human comfort – comfort chart and limitations – effective temperature – factors governing effective temperature – design considerations.

Module 3 (10 Hours)

Cooling load calculations – various heat sources contributing heat load – solar load -- equipment load -- infiltration air load -- duct heat gain -- fan load -- moisture gain through permeable walls and fresh air load, Design of air conditioning systems.

Duct design – equal friction method -- static regain method -- velocity reduction method, Air distribution systems, Analysis for heating and cooling systems, Insulation.

Module 4 (10 Hours)

Heating systems – warm air systems – hot water systems – steam heating systems – panel and central heating systems, Heat pump circuit, Heat sources for heat pump.

Air conditioning equipments and control systems – air filters – humidifiers – fan – blowers – control systems for temperature and humidity – noise control.

Installation and charging of refrigeration unit, Testing for leakage, Cause for faults and

rectification. **References**

1. Noman C. Harris, *Modern Air conditioning Practice*, 2nd ed., McGraw-Hill, 1974.
2. Stoecker, W.F., *Refrigeration & Air conditioning*, 2nd ed., McGraw Hill, New York, 1987.
3. Dossat, R.J., *Refrigeration & Air conditioning*, 4th ed., prentice hall, 1997.
4. Arora, C.P., *Refrigeration & Air conditioning*, 2nd ed., McGraw Hill,, 2000.
5. Stoecker, W.F., *Principles of Air conditioning*, 2nd ed., industrial press, 1977.
6. Laub, J.M., *Heating & air conditioning of buildings*, Holt, Rinehart and Winston, 1963.
7. Kell, J.R., and Martin, P.L., *Air conditioning & Heating of buildings*, 6th ed., Architectural Press, 2007.
8. Carrier's *Handbook for Design of Unit Air Conditioners*, 14th ed., Kenrick Place Media Ltd, 1996.

ME4030 FUNDAMENTALS OF COMBUSTION

L	T	P	C
3	0	0	3

Prerequisite: ME2014 Thermodynamics

Total Hours: 42

Module 1 (12 hours)

Introduction to combustion, Flames classification, First law of thermodynamics, Combustion stoichiometry, Reactants and products, Standard enthalpies and enthalpy of formation – Enthalpy of combustion and heating, Adiabatic flame temperatures, Second law of thermodynamics - Gibb's function.

Module 2 (11 hours)

Chemical kinetics, Global and elementary reactions, Reaction rates, Rate laws and reaction orders, Temperature and pressure dependence on rate coefficients, Unimolecular and bimolecular reactions – Chain and chain-branching reactions, H_2–O_2 chemical mechanisms, Explosion limits.

Module 3 (12 hours)

Premixed laminar flames – Laminar flame structure, Flame velocity and flame thickness, Simplified analysis of laminar flame, Effect of equivalence ratio on flame speed and flame thickness, Flame quenching and ignition - Flammability limits, Laminar diffusion flames – Structure of diffusion flame from Laminar Jets.

Module 4 (7 hours)

Introduction to turbulent flames, Droplet combustion and its applications – Simple Model for evaporating and burning droplet - D^2 Law - Pollutant emissions - Effects of Pollutants - Emission Index.

References

1. Stephen R.T., *An Introduction to Combustion: Concepts and Applications*, 2nd ed., McGraw-Hill, 2000.
2. Kuo, K.K., *Principles of Combustion*, 2nd ed., Wiley - Interscience, 2005.
3. Warnatz, J., Maas, U., and Dibble, R.W., Combustion: *Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation*, 4th ed., Springer-Verlag, 2005.
4. Glassman, I., and Yetter, R.A., *Combustion*, 4th ed., Academic Press, 2008.
5. Williams, F.A., *Combustion Theory*, 2nd ed., Westview Press, 1994.
6. Borman, G, and Ragland, K., *Combustion Engineering*, McGraw Hill, 1998.

ME4031 REFRIGERATION AND AIR CONDITIONING SYSTEMS

Prerequisite: Nil

Total Hours 42

L	T	P	C
3	0	0	3

Module 1 (11 Hours)

Principles of refrigeration – Carnot refrigeration cycle – Various methods of producing cold, Performance parameters – capacity – Coefficient of performance (COP), Refrigeration systems – Vapour compression system – theoretical and practical cycles, System components – Compressors – Condensers – Expansion devices – Evaporators, Other refrigeration systems – Vapour absorption system – Air cycle refrigeration – Steam jet refrigeration – thermo electric cooling and magnetic refrigeration, Introduction to liquefaction systems Cascading – simple Linde Hampson system – Claude cycle liquefier.

Module 2 (11 Hours)

Vapour compression refrigeration system – theoretical and practical cycles – simple and multi-pressure systems – thermodynamic analysis, System components – Compressors – Reciprocating compressors – single and multistage compressors – work of compression – effect of clearance – effect of inter-cooling – optimum pressure ratio – efficiencies – rotary compressors – screw type and vane type compressors – hermetic, semi hermetic and open compressors, condensers – water cooled and air cooled condensers – evaporative condensers, expansion devices – capillary tube – constant pressure expansion valve – thermostatic expansion valve – float valve, evaporators – natural, Vapour absorption system – principle of operation of aqua – ammonia and lithium bromide – water systems – electrolux system – comparison between vapour compression and absorption systems, Refrigerants – thermodynamic, physical and chemical properties of refrigerants – Selection criteria of refrigerants, designating refrigerants.

Module 3 (10 Hours)

Psychrometry – psychrometric processes – determination of air entering conditioned space, Requirement of air conditioning – human comfort – comfort chart and limitations – effective temperature – factors governing effective temperature – design considerations – inside design condition, ventilation standards, Applied psychrometry, summer air conditioning processes, winter air conditioning processes, Other air conditioning systems – summer – winter and round the year air conditioning systems – central and unitary systems.

Module 4 (10 Hours)

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

References

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

ME4032 AUTOMOBILE ENGINEERING

Prerequisite : Nil

Total Hours: 42

L	T	P	C
3	1	0	3

Module 1 (9 Hours)

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

Module 2 (13 Hours)

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

Module 3 (12 Hours)

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

Module 4 (8 Hours)

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

References

1. Joseph Heitner, *Automotive mechanics Principles and Practices*, 2nd ed., D. Van Nostrand Company, 1967.
2. Newton. K and Steeds.W., *The Motor Vehicle*, The English Language Book Society and Newnes Butterworth, London, 1972.
3. William H Crouse and Donald L Anglin, *Automotive Mechanics*, 10th ed., Pearson Higher Education, 1993.
4. William H Crouse and Donald L Anglin, *Automotive engine*, 8th ed., McGraw-Hill, 1994.
5. William H Crouse and Donald L Anglin, *Automotive fuel - lubricating and cooling systems.* 6th ed., McGraw- Hill, 1981.
6. William H Crouse and Donald L Anglin, *Automotive chassis and body.* 5th ed., McGraw-Hill, 1975.
7. William H Crouse, *Automotive electrical equipments.* 8th ed., McGraw-Hill, 1976.
8. Kirpal Singh, *Automobile Engineering Vol. I & II,* 8th ed., Standard Publishers Distributors, Delhi, 1999.

ME4033 INTRODUCTION TO COMPUTER GRAPHICS

Prerequisite: ZZ1004 Computer Programming

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (11 hours)

Introduction to computer graphics - Overview of computer graphics, Mathematics for computer graphics - Representing and interfacing with pictures, Description of graphic devices, Raster Scan Graphics, Algorithms for generating line, circle and ellipse – Polygon filling - Fundamentals of anti-aliasing.

Module 2 (11 hours)

Two-dimensional transformations, Three-dimensional transformations – scaling, shearing, rotation, reflection, translation. Affine and perspective geometry - Orthographic, axonometric and oblique projections: perspective transformations.

Module 3 (10 hours)

Plane curves, non-parametric and parametric curves: Space curves – Representation of space curves, cubic spline, Bezier curves, B-spline curves, NURBS.

Module 4 (10 hours)

Surface description and generation- Surface of revolution, Sweep Surface, Linear Coons surface, Bezier surface, B-Spline surface, B-Spline surface filling, Introduction to solid modelling, Hidden lines and Hidden Surfaces.

References

1. Rogers, D.F., and Adams, J.A., *Mathematical Elements for Computer Graphics,* 2nd ed., Tata McGraw Hill, 2009.
2. Rogers, D.F., *Procedural Elements for computer Graphics,* 2nd ed., Tata McGraw Hill, 1997.
3. Hearn, D., and Baker, M.P., *Computer Graphics,* 2nd ed., Prentice Hall of India Private Limited, 2007.
4. Foley, J.D., Dam, A.V., Feiner, S.K., and Hughes, J.F., *Computer Graphics: Principles and Practice in C,* 2nd ed., Addison-Wesley Professional, 1995.
5. Mortenson, M.E., *Geometric Modeling,* 2nd ed., John Wiley & Sons, 1997.

ME4034 EXPERIMENTAL METHODS IN FLUID FLOW AND HEAT TRANSFER

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (11 hours)

Introduction to experimental methods – basic concepts – accuracy – precision– resolution– uncertainty, Pressure measurements – dynamic response considerations – dead-weight tester – bourdon-tube pressure gage – diaphragm and bellows gages – bridgman gage – pirani thermal-conductivity gage – knudsen gage – ionization gage – alphatron.

Module 2 (11 hours)

Flow measurement – passive-displacement methods – flow-obstruction methods – sonic nozzle – flow measurement by drag effects – pressure probes – hot-wire and hot-film anemometers – magnetic flowmeters, Flow visualization methods – smoke methods – shadowgraph – schlieren photography – laser doppler anemometer – laser-induced fluorescence – particle image velocimetry.

Module 3 (10 hours)

Temperature measurements – temperature scales – ideal-gas thermometer – temperature measurement by mechanical effects – temperature measurement by electrical effects – temperature measurement by radiation – transient response of thermal systems – thermocouple compensation – temperature measurements in high-speed flow – interferometric method.

Module 4 (10 hours)

Transport-property measurements – thermal conductivity measurements – measurement of viscosity – gas diffusion – calorimetry – convective heat transfer measurement – humidity measurement – heat flux meters – pH measurement, Thermal-radiation measurements – emissivity measurement – reflectivity and transmissivity measurement – solar radiation measurement.

References

1. J.P. Holman, *Experimental Methods for Engineers*, McGraw-Hill Company.
2. Figliola, Richard S, & Beasley, Donald E, *Theory and Design for Mechanical Measurements*, Third edition, John Wiley & Sons Inc.
3. Doebelin, Ernest O., *Measurement Systems*, 4th edition, McGraw-Hill International.

ME4122 MECHANICAL BEHAVIOUR AND TESTING OF MATERIALS

Prerequisite: ME2101 Materials Science and Metallurgy

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (8 hours)

Concepts of crystals, Plastic deformation by slip and twinning, Slip systems in FCC, BCC and HCP lattices, Critical resolved shear for slip, Theoretical shear strength of solids, Stacking faults and deformation bands.

Module 2 (14 hours)

Observation of dislocations, Geometric properties of dislocations, Edge and screw dislocations, Climb and cross slip, Dislocations in FCC and HCP lattice, Partial dislocations, Stress fields and energies of dislocations, Forces between dislocations. Applications of dislocation theory, Strengthening from grain boundaries, Grain size measurements, Yield point phenomenon, Strain aging, solid solution strengthening, Strengthening from fine particles, Fiber strengthening, Cold working and strain hardening, Annealing of cold worked metal.

Module 3 (12 hours)

Fracture in metals, Griffith theory of brittle fracture, Metallographic aspects of fracture, Fractography, Dislocation theories of brittle fracture, Ductile fracture, Notch effects, Fatigue of metals, The S-N curve, Low cycle fatigue, Fatigue crack propagation, Effects of metallurgical variables and fatigue, Corrosion fatigue, Effect of temperature on fatigue. Creep and stress rupture, Creep curve, mechanism of creep formation, Stress rupture test, Activation energy for steady state creep, Fracture at elevated temperature, Creep resistant alloys.

Module 4 (8 hours)

Tension test, Stress-strain curves, Instability in tension, Ductility measurement, Effect of strain rate, temperature and testing machine on flow properties, Stress relaxation testing. Hardness test, Brinell, Rockwell and Vickers hardness, flow of metal under the indenter, relationship between hardness and flow curve, micro hardness testing. Torsion test, Mechanical properties in torsion, Torsion stresses for large plastic strains, Types of torsion failures, and torsion testing.

References

1. George, D.M., *Mechanical Metallurgy*, McGraw – Hill Inc, 2001.
2. Hertzberg, R.W., *Deformation and Fracture Mechanics of Engineering Materials*, 4th ed., John Wiley & Sons, 1995.
3. McClintock, F.A., and Argon, A.S., Mechanical Behavior of Materials, 1st ed., Addison-Wesley Publications, 1966.
4. Reed Hill, R.E., *Physical Metallurgy Principles*, 2nd ed., Affiliated East-West Press, 2008.
5. Hayden, H.W., *Structure And Properties Of Materials: Mechanical Behaviour Vol. 3 (Structure & Properties Of Materials)*, John Wiley & Sons Inc, 1965.
6. Honeycombe, R.W.K., *Plastic Deformation of Metals*, 2nd ed., Edward Arnold, 1984.

ME4123 TECHNOLOGY MANAGEMENT

L	T	P	C
3	0	0	3

Prerequisite: Nil

Total Hours: 42

Module 1 (12 hours)

Technology – definition and characteristics, Management of technology, Process of technological change, Technology life cycles – the S-curve of technological process, Diffusion of technology.

Module 2 (10 Hours):

Critical factors in managing technology, Technology and competition – competitive consequences of technological change.

Module 3 (10 Hours):

Technology Strategy – strategic impact of technology – Transfer of technology -Technology intelligence – Collaborative mode, Appropriation of technology.

Module 4 (10 Hours):

Technology evaluation and financing, Technology audits, Intellectual property rights – patents – trade secrets – trade marks – copyrights.

References

1. Khalil, T., *Management of Technology*, Tata McGraw-Hill, 2009.
2. Narayanan, V.K., *Managing Technology and Innovation for Competitive Advantage*, Pearson Education Asia, 2001.
3. Burgelman, R.A., Christensen, C.M., and Wheelwright, S.C., *Strategic Management of Technology Innovation*, McGraw-Hill, 2004.
4. Shane, S., *Technology Strategy for Managers and Entrepreneurs*, Pearson Education, Inc., 2009.
5. Gaynor, G.H., *Handbook of Technology Management*, McGraw-Hill, 1996.

ME4125 COMPETITIVE MANUFACTURING MANAGEMENT

Pre-requisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (10 hours)

Evolution of manufacturing, Modern developments, E-manufacturing – e-manufacturing and supply chain – business process design models and concepts, Continuous improvement, Process reengineering, Basic problem solving and improvement tools, Just-In-Time (JIT) – value added focus – sources of waste – JIT Principles.

Module 2 (10 hours)

TQM – framework for managing total quality – employee involvement – benchmarking – quality certification and awards, Statistical process control – variation in processes – control charts – process capability, Six sigma quality – methodology.

Module 3 (10 hours)

Lean production – small lot production – setup time reduction – pull production – pull and push systems – kanban.

Module 4 (12 hours)

Focused factories and group technology – ways of doing work – facility layout – part families and machine groups – production flow analysis, Cellular manufacturing – part family/machine cell formation methods – linked cells – workcell design – workcell capacity – staffing a workcell.

References

1. Nicholas, J., *Competitive Manufacturing Management – Continuous Improvement, Lean Production, and Customer-Focused Qualities*, McGraw-Hill Edition, 2001.
2. Greeff, G., and Ghoshal, R., *E-manufacturing and Supply Chain Management*, Elsevier, 2004
3. Sing, N., and Rajamani, D., *Cellular Manufacturing Systems: Design, Planning & Control*, 1st ed., Chapman & Hall, 1996.
4. Askin, R.G., and Standridge, C.R., *Modelling and Analysis of Manufacturing Systems*, John Wiley & Sons. Inc, 1993.
5. Mikell P. Groover (2001). *Automation, Production Systems, and Computer-Integrated Manufacturing*, 2nd ed., Prentice-Hall of India Private Limited.
6. Bedworth, D.D., Henderson, M.R., and Wolfe, P.M., *Computer-Integrated Design and Manufacturing*, McGraw-Hill International Edition, 1991.
7. Chang, T-C, Wysk, R.A., and Wang, H-P, *Computer-Aided Manufacturing*, 2nd ed., Prentice-Hall International, Inc, 1998.

ME4126 ENGINEERING OPTIMIZATION

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (10 hours)

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

Module 2 (10 hours)

Integer programming, Mathematical formulations, Zero-one problems – additive algorithm, Gomory's cutting plane algorithm, Branch and bound algorithm, All integer primal algorithm, All integer dual algorithm, Mixed integer programming – cutting plane algorithm and Bender's partitioning algorithm.

Module 3 (10 hours)

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

Module 4 (12 hours)

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

References

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

ME4127 ACCOUNTING AND FINANCE FOR ENGINEERS

Prerequisite: Nil

Total Hours: 42 hours

L	T	P	C
3	0	0	3

Module 1 (10 Hours)

Finance and related discipline – scope – function, Time value of money, **S**tocks and bond valuation, Sources of corporate finance – capital market.

Module 2 (11 Hours)

Financial Accounting – need – concepts, Journal, Ledger, Trial balance, Profit and loss account – Construction, Balance sheet – Construction – accounting equation, accounting softwares.

Module 3 (11 Hours)

Financial statement analysis – ratio analysis, Statement of changes in financial position, Working capital basis.

Module 4 (10 Hours)

Financial planning – budgeting - working capital computation, Capital budgeting – traditional and discounted cash flow techniques – NPV – IRR comparisons

References

1. Khan M.Y. and Jain P.K., ―*Financial Management*‖, 3rd ed., Tata McGraw-Hill, 2003.
2. Jawahar Lal, ―*Financial Accounting*‖, 2nd ed., Wheeler publishing, 2000.
3. I.M. Pandey, *"Financial Management*‖, 8th ed., Vikas publishing house, 2003.
4. Prasanna Chandra, *"Financial Management*‖, 4th ed., Tata McGraw-Hill, 2003.

ME4128 SIMULATION MODELLING AND ANALYSIS

Prerequisite: Nil

L	T	P	C
2	1	0	3

Total Hours: 42

Module 1 (10 hours)

Systems and system environment, Components of a system, Discrete and continuous systems, Model of a system, Types of models, Steps in simulation study, Technique of simulation, Comparison of simulation and analytical methods, Monte Carlo simulation.

Module 2 (10 hours)

Simulation of queuing systems – simulation of inventory systems – concept in discrete event simulation, Random number generation – techniques for generating random numbers, Test for random numbers – frequency tests and tests for autocorrelation, Random variate generation – inverse transform method and acceptance rejection technique.

Module 3 (10 hours)

Input modelling for simulation – data collection, Identifying the distribution with data, Parameter estimation, Goodness of fit tests – chi square and kolmogorov smirnov tests, Verification and validation of simulation models.

Module 4 (12 hours)

Output analysis for a single model – measures of performance and their estimation, Output analysis for terminating simulations and steady state simulations. Introduction to simulation software – simulation model building using ARENA and Excel.

References

1. Banks, J., Carson, J.S., Nelson, B.L., and Nicol, D.M., *Discrete–Event System Simulation*, Pearson Education, Inc., 2007.
2. Law, A.M., and Kelton, W.D., *Simulation Modelling and Analysis*, McGraw Hill International, 2000.
3. Gordon, G., *System Simulation*, Second Edition, Prentice Hall of India, 1995.
4. Ross, S.M., *Simulation*, Third Edition, Academic Press, 2002.
5. Fishman, G.S., *Concepts and Methods in discrete Event Digital Simulations*, Wiley, New York, 1973.
6. Oakshott, L., *Business Modelling and Simulation*, Pitman Publishing, 1997.
7. Carrie, A., *Simulation of Manufacturing Systems*, John Wiley & Sons Ltd., 1988.
8. Rossetti, M.D., *Simulation Modeling and ARENA*, John Wiley, 2009.

ME4129 MODELLING OF MANUFACTURING SYSTEMS

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42

Module 1 (8 hours)

Modelling automated manufacturing systems – role of performance modelling, Performance modelling tools – simulation models and analytical models, Automated manufacturing systems – input-output model, Plant configurations, Performance measures.

Module 2 (12 hours)

Computer controlled machines – NC machines, Pallets and fixtures, Machining centers, Automated inspection systems, Material handling systems – conveyors – industrial robots – automated guided vehicles – storage and retrieval systems, Facility layout – CRAFT – quadratic assignment problem, Group technology – coding schemes – production flow analysis – mathematical model, Flexible manufacturing systems – architecture of FMS – automated workpiece flow – automated assembly systems – deadlocks – performance measures.

Module 3 (10 hours)

Markov chain models, Geometric and exponential random variables, Stochastic processes – Poisson process, Discrete-time Markov chains, Continuous-time Markov chains, Markov model of a transfer line, Birth and death processes in manufacturing.

Module 4 (12 hours)

Basic queuing models – (M/M/1) – (M/M/m), Queues with breakdowns, Analysis of a flexible manufacturing center, Queuing networks – open – closed – product form, Queuing networks with blocking, Application of queuing models for manufacturing systems – simulation models for serials lines and flexible manufacturing.

References

1. Viswanadham, N., and Narahari, Y., *Performance modeling of automated manufacturing systems*, Prentice-Hall of India, New Delhi, 1996.
2. Askin, R.G., and Standridge, C.R., *Modeling and Analysis of manufacturing systems*, John Wiley & Sons, 1993.
3. Altiok, T., *Performance Analysis of Manufacturing Systems*, Springer, 1997.
4. Brandimarte, P., and Villa, A., *Performance modeling of automated manufacturing systems*, Prentice-Hall of India, New Delhi, 1996.
5. Curry, G.L., and Feldman, R.M., *Manufacturing systems modeling and analysis*, Springer, 2011.

ME4130 HUMAN FACTORS IN ENGINEERING AND DESIGN

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 42 hours

Module 1 (10 Hours)

Human factors and Systems, Nature of man-machine systems and characteristics, Information input and processing – information theory – displaying information – coding of information – mode of information processing, Perception, Attention, Mental Workload, Human Factors in information revolution

Module 2 (10 Hours)

Test, Graphics, Symbols and Codes, Visual capabilities – visual display terminal screens and text, Graphic representations, Symbolic designs – Quantitative visual displays – signals and warning lights, Representational displays – auditory – tactual and Olfactory Displays – Cutaneous senses – Speech communication.

Module 3 (12 Hours)

Human motor activity, Muscle physiology, Measure of physiological strain – physical workload – strength and endurance, Manual material handling, Recommended limits, Motor skills, Human control of systems.

Module 4 (10 Hours)

Anthropometry and work-space design – use of anthropometric data, Design of work surfaces – science of seating, General location of control and displays within work space, Interpersonal aspects of workplace design.

References

1. Sanders, M.S., and McCormick, E.J., *Human Factors in Engineering and design*, 7th ed., McGraw-Hill International.
2. Murrell, K.F.H., and Schnauber, H., *Ergonomics. Econ*, Munich, 1986.
3. Gavriel, S., *Handbook of Human Factors & Ergonomics*, Inter-science, 1997.

ME3114 CAD/CAM/CIM

Prerequisite: Nil

Total Hours: 42

L	T	P	C
3	0	0	3

Module 1 (9 hours)

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

Module 2 (11 hours)

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

Module 3 (11 hours)

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

Module 4 (11 hours)

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

References

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

ME4131 INTRODUCTION TO TURBULENCE

Prerequisite: Mechanics of Fluid

Total Hours: 42

L	T	P	C
3	0	0	3

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

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

Module 3 (8 hours)
The concept of vorticity dynamics, Energy producing Large eddies and dissipative eddies, vortex stretching, Concept of energy cascading, Kolmogorov Energy spectrum.
Developing and Fully Developed Turbulent Flow in a pipe for Moderate Reynolds Number, variation of friction factors and shear stresses.

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

Text Books

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

List of Electives

No.	Code	Subject
1	ME3021	Introduction to Finite Element Methods
2	ME3022	Experimental Stress Analysis
3	ME3023	Theory of Plasticity
4	ME3024	Control Systems Engineering
5	ME3025	Nonlinear Dynamics and Chaos
6	ME3026	Engineering Fracture Mechanics
7	ME3027	Fluid Power Controls
8	ME3028	Advanced Thermodynamics
9	ME3029	Computational Methods in Engineering
10	ME3121	Powder Metallurgy
11	ME3122	Introduction to Marketing
12	ME3123	Design and Analysis of Management Information Systems
13	ME3124	Work Design and Measurement
14	ME3125	Cost Analysis and Control
15	ME3126	Supply Chain Management
16	ME3127	Management of Organisational Behaviour
17	ME3128	Production Planning and Control
18	ME3129	Management of Human Resources
19	ME3130	Quality Planning and Analysis
20	ME4021	Industrial Tribology
21	ME4022	Vehicle Dynamics
22	ME4023	Introduction to Robotics
23	ME4024	Design for Manufacturability
24	ME4025	Mechatronics
25	ME4026	Unconventional Energy Systems
26	ME4027	Computational Fluid Dynamics
27	ME4028	Aerodynamics
28	ME4029	Heating, Ventilation and Air Conditioning
29	ME4030	Fundamentals of Combustion
30	ME4031	Refrigerating and Air Conditioning Systems
31	ME4032	Automobile Engineering
32	ME4033	Introduction to Computer Graphics
33	ME4034	Experimental Methods in Fluid Flow and Heat Transfer
34	ME4122	Mechanical Behaviour and Testing of Materials
35	ME4123	Technology Management
36	ME4125	Competitive Manufacturing Management
37	ME4126	Engineering Optimization
38	ME4127	Accounting and Finance for Engineers
39	ME4128	Simulation Modelling and Analysis
40	ME4129	Modelling of Manufacturing Systems
41	ME4130	Human Factors in Engineering and Design
42	ME3114	CAD/CAM/CIM
43	ME4131	Introduction to Turbulence