

ME 7.1 HEAT AND MASS TRANSFER

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.1	Heat and Mass Transfer	3	--	2	3	100	25	--	--	--	125

Course Objectives:

1. To develop methodologies for solving a wide variety of engineering problems.
2. To estimate Heat Transfer rates and the consequent temperature distributions
3. To design and analyses practical applications
4. To understand mass transfer phenomenon and to estimate mass transfer rates various practical scenarios

Course Outcomes:

1. Understand the basic laws of heat transfer.
2. Understand the consequence of heat transfer in thermal analysis of engineering systems.
3. Analyze problems involving steady state heat conduction in simple geometries.
4. Develop solutions for transient heat conduction in simple geometries.
5. Understand the fundamentals of convective heat transfer process.
6. Evaluate heat transfer coefficients for natural convection.
7. Evaluate heat transfer coefficients for forced convection.
8. Analyze heat exchanger performance by using the method of log mean temperature difference.
9. Analyze heat exchanger performance by using the method of heat exchanger effectiveness.

UNIT-1

(12 hours)

Introduction to Heat Transfer and Concepts: Thermodynamics versus Heat Transfer, Modes of heat Transfer, Basic laws of Heat Transfer, Problems.

Conduction: General heat conduction equation in cartesian, cylindrical & spherical coordinates, Initial and Boundary conditions, One-dimensional steady-state conduction: plane walls & composite plane walls, hollow and composite cylinders and spheres, Thermal contact resistance, Critical radius of Insulation - spheres & cylinders, Variable thermal conductivity, Economic Thickness of Insulation.

Conduction with Heat Generation: Plane wall with uniform heat generation, Cylinder with uniform heat generation, sphere with uniform heat generation.

UNIT-2

(12 hours)

Heat Transfer from Extended Surfaces: Generalized Fin Equation, Heat dissipation from fins: infinitely long fin, insulated fin, fin losing heat at the tip, Fin effectiveness & efficiency, Thermometric well.

Transient Heat Conduction: Lumped Parameter analysis, Transient heat conduction in large plane walls, long cylinders and spheres using Heisler charts.

Heat Exchangers: Classification of Heat Exchangers, Overall heat transfer coefficient, The LMTD Method for Heat exchanger analysis, Correction for LMTD for use with cross flow & multipass exchangers, ϵ – NTU method for heat exchanger analysis.

UNIT-3

(12 hours)

Forced Convection: Physical Mechanism of forced Convection, Velocity boundary layer – laminar & turbulent flows , Reynolds number, Thermal Boundary layer, Flow over flat plates – laminar flow , turbulent flow, Combined Laminar & turbulent flow , Flow across Cylinders & spheres –the Drag coefficient, the heat transfer coefficient , Flow in tubes.

Natural Convection: Physical Mechanism of Natural Convection – Grashof's number, Natural Convection over surfaces – natural convection correlations, Natural Convection inside enclosures – effective thermal conductivity, Natural convection from finned surfaces, Combined Natural and Forced convection.

Boiling and Condensation: Boiling heat transfer, pool boiling regime, condensation heat transfer, film condensation – vertical plate, sphere, horizontal cylinders, Dropwise condensation.

UNIT-4

(12 hours)

Radiation Heat Transfer: Thermal Radiation, Blackbody radiation , Radiation properties, Planck's law, Stefan Boltzman's Law, Wien's Displacement Law, Kirchoff's law, Gray body & selective emitters, Intensity of Radiation & Lambert's Cosine Law, Atmospheric and solar radiation.

Radiation Exchange between Surfaces: The view factor, View Factor Algebra, Radiation heat transfer – black surfaces, diffuse and gray surfaces, Surface and space resistance, Electrical approach between for radiation heat exchange, Radiation shields.

Mass Transfer: Introduction to Mass transfer, Modes of Mass Transfer, Fick's law of diffusion , General mass diffusion equation in stationary media, Steady state diffusion through a plain membrane, Steady state equimolar counter diffusion, Diffusion in Gases, liquids and solids, The mass-transfer coefficient, Evaporation process in the atmosphere, Convective mass transfer and Correlations for mass transfer.

Recommended Readings:

1. N. M. Ozisik; Heat transfer - A basic approach; McGraw-Hill Publication; 1985.
2. J. P. Holman; Heat Transfer; McGraw-Hill Publication; 1996.
3. J. Taine, J. Petit; Heat Transfer; Prentice Hall India; 1993.
4. Y. A. Cengel; Heat transfer -A Practical Approach; McGraw Hill Publication; 1998.
5. R. K. Rajput; Heat & Mass Transfer; S. Chand & Co.; 2012.
6. Dr. D.S. Kumar; Heat and Mass Transfer; S. K. Kataria & sons; 2013.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Thermal Conductivity of a plane and/or composite wall.
2. Thermal Conductivity of a Composite cylinder.
3. Thermal Conductivity of a composite sphere.
4. Analysis of a parallel flow heat exchanger.
5. Analysis of a counter flow heat exchanger.
6. Analysis of a shell type heat exchanger using Logarithmic Mean Temperature method.
7. Analysis of a shell type heat exchanger using Effectiveness method.
8. Estimation of Forced Convection heat transfer coefficient.
9. Estimation of Natural Convection heat transfer coefficient.
10. Performance test on forced convection cooling tower test rig.
11. Estimation of Stefan Boltzman Constant.
12. Measurement of emissivity of test plate (Gray Body).
13. Performance evaluation on Critical Heat flux apparatus.
14. Study of heat pipe and its demonstration.

ME 7.2 INDUSTRIAL ENGINEERING AND OPERATIONS MANAGEMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.2	Industrial Engineering and Operations Management	4	1	--	3	100	25	--	--	--	125

Course Objectives:

1. To understand the concept of productivity
2. To understand methods of improving existing methods
3. To study methods of establishing work standard
4. To understand the role of operations manager
5. To study the techniques for effective management of operations.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand the work study aspect of the jobs.
2. Analyze the work content of the jobs.
3. Develop more efficient ways of doing a job.
4. Understand the method to set time standards for the jobs.
5. Understand how the Operations Manager fits into the organization.
6. Develop quantitative and qualitative analysis skills needed for managing operating systems.
7. Understand modeling concepts which can be used to help managers evaluate various management problems.

UNIT - 1

(16 Hours)

Productivity: Definition, measurement, scope, Partial and total productivity, Means of increasing productivity.

Work Study: Definition, objectives, procedure, Work content analysis, Work study as a means of improving productivity, Human factor in the application of work study.

Method Study: Definition, objectives, procedure, Selection of a job, Recording techniques – Charts-Outline, Flow process, two-handed, multiple activity and travel chart, Diagrams- Flow and string diagram, Critical examination, Design cycle of Method Study.

Principles of Motion Economy and Ergonomics: Use of human body, arrangement of the work place, design of tools and equipments, Ergonomics and Safety.

Introduction to Value Engineering.

UNIT - 2

(16 Hours)

Work Measurement: Definition, objectives, Techniques of work measurement.

Time Study: Definition, Time Study Equipment's, Job selection, Steps in time study, Breaking jobs into elements, Systems of rating, Standard rating, Performance rating, Scales of rating, Allowances, Calculation of standard time, Predetermined Motion time study (PMTS), Introduction to Maynard Operational Sequential Technique (MOST).

Work Sampling: Definition, procedure, determination of sample size.

Introduction to Job Evaluation and Merit Rating.

Wages and Incentives: Definition, need, Elements of ideal wage system, types of wages - Time wage system, Piece wage system, Characteristics, types of incentives plans - Financial and Non-financial, Individual and Group Incentives schemes - Taylors differential piece rate plans, Halsey premium plan, Emerson Efficiency plan.

UNIT - 3

(16 Hours)

Forecasting Techniques: Forecasting as a planning tool, forecasting time horizon, short and long range forecasting, sources of data, types of forecasting, qualitative forecasting techniques, quantitative forecasting models - Linear regression, Moving average, Weighted moving average, Exponential smoothing, Exponential smoothing with trends, Techniques for seasonality cycles, techniques for cycles, Measurement of errors, accuracy and control of forecast.

Plant Location: Need and nature of location decisions, factors affecting location decisions and their relative importance for different types of facilities, Evaluating Location alternatives – Break Even Analysis, Factor Rating, Center of Gravity Method.

Plant Layout: Layout and its objectives, principles, types of plant layouts – product layout, process layout, fixed position layout, cellular manufacturing layouts, Factors influencing layout changes.

Assembly Line Balancing: Concept of work stations, cycle time, idle time. Assigning task to work station using single rule or combination of rules - task times, following tasks, positional weight.

UNIT - 4

(16 Hours)

Aggregate Planning and Master Production Scheduling: Purpose and scope, basic strategies of aggregate planning, Master scheduling.

Sequencing and Scheduling: Sequencing, Priority rules, Single processor system, Two processor and Three processor systems, Johnson's rule, Scheduling operations, Gantt chart.

Inventory Management: Dependent and independent demand. Inventory control - ABC analysis, EOQ models for purchasing and manufacturing situation with shortages, Introduction to Supply Chain Management.

Project Management and Network Analysis: Introduction, Network construction - AON and AOA diagrams, CPM and PERT analysis, Crashing of simple projects, Resource allocation.

Recommended Readings:

1. K. George; Introduction to work study by ILO; Universal Book Corporation, Bombay, 2011.
2. M. Telsang; Industrial Engineering and Production Management; S. Chand, New Delhi; 2015.
3. W. J. Stevenson; Operation Management; McGraw Hill, New York; 2005.
4. R. M. Barnes; Motion and Time study - Design and Measurement of Work; Wiley and Sons; New York; 1980.
5. J. G. Monks; Operations Management: Theory and Problems; McGraw Hill, New

York; 1987.

6. A. P. Verma; Industrial Engineering & Management; S. K. Kataria & Sons; 2012.
7. M. Mahajan; Industrial Engineering and Production Management; Dhanpat Rai & Co.; 2014.

Assignments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.3 CAD and FEA

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.3	CAD and FEA	3	1	2	3	100	25	--	25	--	150

Course Objectives:

1. To understand CAD process, CAD hardware and software and geometric modeling concepts
2. To understand computer graphics so as to visualize the graphic images, geometric models etc. on the screen
3. To understand the basic concepts of finite element analysis
4. To understand the mathematical modeling of physical problems using direct stiffness method and potential energy method
5. To use commercial software to solve structural engineering problems

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Model the geometry of mechanical components, parts etc. using CAD software
2. Analyze and design the mechanical components, parts etc. using CAD software
3. Use direct stiffness method and potential energy method to solve problems in structural engineering
4. Use FEA commercial software to solve engineering problems related to structures, heat transfer, fluid mechanics

UNIT -1

(12 Hours)

Introduction to CAD/CAM, Fundamentals of CAD, CAD Hardware, CAD Software, Geometric modeling – Classification, Construction methods, Constraint based modeling, Other modeling methods, Curve and surface representation, CAD standards, CAD database, CAD/CAM data exchange, Concurrent engineering, Artificial intelligence in CAD.

UNIT - 2

(12 Hours)

Introduction to computer graphics, Raster scan graphics, Digital Differential Analyzer, Bresenham's line drawing algorithm, Bresenham's circle generation algorithm, Real time scan conversion, Run length encoding, Character display, Clipping, Cohen-Sutherland line clipping algorithm, Midpoint subdivision algorithm, Sutherland-Hodgman polygon clipping algorithm, Geometric transformations, Hidden surface removal, Back face algorithm, Depth buffer algorithm.

UNIT - 3

(12 Hours)

Numerical Solution Of Differential Equations: Taylor's series method, Euler's method, Modified Euler's method, Runge Kutta methods.

Numerical Solution of Partial Differential equations: Solution of Laplace equation, heat equation and wave equation by finite difference method.

Numerical Integration: Newton- Cote's quadrature formula, Trapezoidal rule, Simpson's 1/3 and 3/8 rules.

Solution of Linear Algebraic Equations: Gauss Elimination method, Gauss Jordan method, Jacobi's method, Gauss-Siedel iterative method.

UNIT - 4

(12 Hours)

Introductory Concepts: Introduction to FEM, Discrete and continuous system, Need for numerical methods of solution, General steps of the finite element method, Engineering applications of FEM in various fields, Advantages of FEM, Types of elements.

Discrete Systems: Generation of matrix displacement equation for spring element and 1-D bar element using direct and potential energy approach, Solution for displacements, forces, reaction, stresses.

Trusses: Stiffness matrix for a truss, Assembling of global stiffness matrix, Solution for displacements, forces, reaction, stresses, Band width of a matrix.

Brief Overview of Convergence and Mesh Generation: Requirements for convergence, h-refinement and p-refinement, Pascal's triangle, Displacement models, Shape functions for 1-D linear, quadratic and cubic elements in terms of local, global and natural coordinate system.

Recommended Readings:

1. P. N. Rao; CAD/CAM: Principals and Applications; Tata McGraw-Hill Publishing Company Ltd.; 2e; 2004.
2. M. P. Groover, E. W. Zimmers, Jr.; CAD/CAM: Computer-Aided Design and Manufacturing; Prentice-Hall of India Pvt. Ltd.; 2000.
3. D. F. Rogers; Procedural Elements for Computer Graphics; Tata McGraw-Hill Publishing Company Ltd.; 2e; 2001.
4. E. Balagurusamy; Numerical Methods, Tata McGraw-Hill Publishing Company Ltd.; 1999.
5. V. Rajaraman; Computer Oriented Numerical Methods; Prentice-Hall of India Pvt. Ltd.; 2002.
6. T. R. Chandrupatla, A. D. Belegundu; Introduction to Finite Elements in Engineering; Prentice-Hall of India Pvt. Ltd.; 1996.

List of Experiments:

1. **CAD:** Solid modeling of any eight 3-D objects, machine parts/ components using any CAD software(s).
2. **FEA:** Practicals to be conducted to solve any two problems using any FEM solver covering FEM analysis of
 - 1D structure/ Heat transfer/ fluid flow problems.
 - 2D Heat transfer/ fluid flow problems and trusses.
 - Beam problems
 - Vibration problems

And shall include the following:

Pre processing: model definition – Nodal coordinates element connectivity, Material and element type and property definitions, Type of analysis (static/modal), Using loading and boundary conditions.

Meshing techniques - Free and mapped meshing, Quality checks – aspect ratio, warp angle, skew, Jacobian, distortion, stretch, included angle, taper.

Processing: Element level calculations, Equation assembly, Equation solver (sparse solvers, Factorization, Numerical/Computational issues).

Post Processing: Strain and stress recovery (integration and nodal points), Interpretation of results (results validation and data interpretation) and design modification.

ME 7.4.1 ADVANCED MECHANICS OF SOLIDS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.1	Advanced Mechanics of Solids	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To make the students familiar with analysis of stress and strain.
2. To make the students comfortable in analyzing asymmetric bending and curved beams.
3. To familiarize the students with the theory of elasticity as applied to planar stresses and strains.
4. To make the students familiar with axisymmetric problems.
5. To familiarize the students with Energy approach to solve structural problems & Rayleigh Ritz method to solve problems in elastic instability.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Analyze stresses and strains in tri-axial loading
2. Apply the concepts of theory of elasticity in solving problems
3. Analyze stresses in axis-symmetric cases
4. Use Energy methods in solving engineering problems.

UNIT - 1

(12 Hours)

Analysis of Stress: Analysis of stress, Tensor notation, Stress transformation, Principal stresses, Octahedral stresses, Mohr's Circle, theories of failure.

Analysis of Strain: Definition, Displacement Field, Strain as Second Order Tensor, Strain transformation, Principal Strains, Mohr's Circle for Strain, Compatibility equations

Asymmetric Bending in Beams: Review of product inertia, stresses due to asymmetric bending in beams.

Curved Beams: Stresses in beams with initial curvature.

UNIT - 2

(12 Hours)

Theory of Elasticity: Constitutive equations, equations of elasticity, uniqueness theorem, principle of superposition, Saint Venant's principle, Airy's stress function. Two-dimensional problems in Cartesian co-ordinate system: viz. bending of narrow cantilever beam of narrow cross section under edge load, simply supported beam of narrow cross section under edge load and simply supported beam subjected to uniformly distributed load.

UNIT - 3

(12 Hours)

Axis-Symmetric Problems: General equations in cylindrical co-ordinates, Thick cylinders under uniform pressure, shrink and force fit, stresses in rotating discs.

Torsion: Torsion of circular and non-circular bars, torsion of thin tubes.

UNIT - 4

(12 Hours)

Energy Methods: Maxwell-Betti's Reciprocal theorem, Castigliano's theorems, principle of virtual work, complementary strain energy, dummy load method, Stationary potential energy. Analysis of structures using energy methods.

Elastic Stability: Buckling of columns, Rayleigh-Ritz method to find critical load for columns.

Recommended Readings:

1. L. S. Srinath; Advanced Mechanics of Solids; Tata McGraw Hill Publishing Company Ltd.; 2009.
2. S. P. Timoshenko, J. N. Goodier; Theory of Elasticity; McGraw Hill Education; 3e; 2010.
3. I. Shames; Introduction to Solid Mechanics; Prentice Hall of India; 3e; 2003.
4. S. M. A. Kazimi; Solid Mechanics, Tata McGraw Hill Education; 1e; 1982.
5. P. N. Singh, P. K. Jha; Elementary Solid Mechanics; New Age International (P) Ltd. Delhi; 2011.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.4.2 ADVANCED ANALYSIS AND SYNTHESIS OF MECHANISMS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.2	Advanced Analysis and Synthesis of Mechanisms	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To develop student understanding of the theoretical background for basic and advanced kinematics and synthesis of mechanisms to achieve desired motion.
2. To synthesize a mechanism for known input and output requirements.
3. To introduce students to basic and advanced computer-based tools for analysis and synthesis of mechanisms.
4. To develop ability to apply kinematic theories to synthesize real life problems.

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Use theoretical background in the analysis and synthesis of mechanisms.
2. Analyze simple and complex mechanisms.
3. Understand advanced computer-based engineering tools for the analysis and design of linkages.
4. Apply theory and practical engineering tools in a substantial mechanism design project.

UNIT - 1

(12 Hours)

Review of Basic Kinematics: Kinematic Analysis of Plane Mechanisms: Displacement, Velocity and acceleration analysis of simple and complex mechanisms by analytical and graphical methods.

UNIT - 2

(12 Hours)

Curvature Theory: Fixed and moving centrodes, envelopes – velocity and acceleration inflection points and inflection circle. Euler – Savary equation, Bobillier's theorem, Hartmans's construction, return circle, cusp points, cubic of stationary curvature, Ball's point, Application in dwell mechanisms.

UNIT - 3

(12 Hours)

Kinematic Synthesis of Plane Mechanisms: Type, number and dimensional synthesis, branch and order defects, Function generation and path generation, rigid body guidance. Chebychev spacing, three, four and five position synthesis, Burmester point theory, synthesis by analytical methods.

UNIT - 4

(12 Hours)

Computer aided kinematic analysis of planar mechanisms.

Spatial Mechanisms: Position, velocity and acceleration analysis of RGG mechanisms, Eulerian angles theorem on angular velocities and acceleration, DH parameters, DH matrix method, application of spatial mechanisms in robotics, Kinematic analysis of industrial robots.

Recommended Readings:

1. A. Ghosh, A. Malik; Theory of Mechanisms and Machines; East West Press; 3e; 2006.
2. J. E. Shigley, J. J. Uicker Jr.; Theory of machines and Mechanisms; Mc Graw , Hill International edition; 2010
3. A. G. Erdman, G. N. Sendor, S. Kota; Mechanism Design - Analysis and synthesis, Pearson Education; 4e; 2001.
4. R. S. Hartenberg, J. Denavit; Kinematic synthesis of Linkages; McGraw-Hill Inc.; 1964
5. D. H. Myszka; Machines & Mechanisms; Pearson Prentice Hall; 3e; 2013.
6. P. E. Nikravesh; Computer – Aided Analysis of Mechanical systems Longman Higher Education; International; 1988.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.4.3 VIBRATION AND NOISE CONTROL

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.3	Vibration and Noise Control	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand fundamentals of vibrations.
2. To understand fundamentals of noise control.
3. To understand the concept of vibration absorbers.
4. To introduce real world problems in structural vibration and noise control.

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Understand the basic concepts of mechanical vibrations
2. Understand causes, source and types of vibrations in machinery
3. Understand knowledge in sources and measurement standard of noise
4. Understand designing and developing vibrations and noise control systems.

UNIT-1

(12 hours)

Basics of Vibrations: Introduction, free and forced vibration, undamped and damped vibration, response of damped and undamped systems under harmonic force, analysis of single degree and two degree of freedom systems, torsional vibration, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.

UNIT-2

(12 hours)

Forced Vibration: Single degree freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, Reciprocating and rotating unbalance, vibration isolation - transmissibility ratio due to harmonic excitation and support motion. Systems with two degrees of freedom: Introduction, principle modes and Normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, vibration absorbers, Vibration isolation, tuned absorbers, un-tuned viscous dampers and applications - dynamic forces generated by IC engines, engine isolation, crank shaft damping, modal analysis of the mass elastic model shock absorbers. Active vibration control.

UNIT-3

(12 hours)

Basics of Noise: Introduction, amplitude, frequency, wavelength and sound pressure level, addition, subtraction and averaging decibel levels, noise dose level, legislation, measurement and analysis of noise, measurement environment, equipment, frequency analysis, tracking analysis, sound quality analysis. Introduction to relation between

vibration and noise, vibration as noise sources, classification of analysis of machinery vibrations.

UNIT-4

(12 hours)

Source of Noise and Control: Methods for control of engine noise, combustion noise, mechanical noise, predictive analysis, palliative treatments and enclosures, automotive noise control principles, sound in enclosures, sound energy absorption, sound transmission through barriers. Noise Generated by Vibrating Structures and Control: Elementary noise radiators; noise radiation by machine; noise source and control.

Recommended Readings:

1. S. S. Rao; Mechanical Vibrations; Pearson Education; 5e; 2010.
2. B. Balachandran, E. B. Magrab; Fundamentals of Vibrations; Cengage Learning, 1e; 2009.
3. M. L. Munjal; Noise and Vibration Control; World Scientific Publishing Company, Singapore; 2013.
4. D. Bies, C. Hansen; Engineering Noise Control – Theory and Practice; E and FN Spon; Taylor & Francis e-Library; 4e; 2009.
5. B. H. Tongue; Principles of Vibrations; Oxford University; 2e; 2007.
6. W. T. Thomson, M. D. Dahleh, C. Padmanabhan; Theory of Vibration with Application; Pearson Education 5e; 2011.
7. G. T. Grover; Mechanical Vibrations; Nem Chand and Bros.; 1996.
8. B. Challen, R. Baranescu; Diesel Engine Reference Book; SAE International; 2e; 1999.
9. J. H. Smith; An Introduction to Modern Vehicle Design; Butterworth -Heinemann; 2004.
10. J. S. Rao, K. Gupta; Introductory course on Theory and Practice of Mechanical Vibration; New Age International Publications; 2e; 2010.
11. A. A. Shabana; Theory of vibrations – An introduction; Springer; 2e; 2010.
12. J. Fenton; Handbook of Automotive body Construction and Design Analysis; Professional Engineering Publishing; 1998.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.4.4 ALTERNATE ENERGY SOURCES

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.4	Alternate Energy Sources	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Understand and analyze the pattern of renewable energy resources
2. Suggest methodologies/technologies for its utilization.
3. Economics of the utilization and environmental merits.
4. Understand general physical mechanism of energy conversion.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand of commercial energy and renewable energy sources
2. Analyze the various renewable energy sources like wind, solar, biomass, Ocean energy, Fuel cells and MHD systems.
3. Understand Biomass gasification and combustion, Theory of flat plate collectors, photo voltaic, thermal applications and limitations of solar energy.
4. Design solar energy, wind energy equipment's and biomass conversion technology utilizing basic principles

UNIT-1

(12 hours)

Introduction: Indian energy scenario, Need, Characteristics and challenges in the successful utilization of renewable energy sources, Jawaharlal Nehru National Solar Mission.

Solar Energy: Solar radiation and its measurements. Theory of flat plate collectors - Photovoltaic and thermal applications, Limitation of solar energy, Solar water heating, solar drying, solar stills, solar cooling and refrigeration.

UNIT-2

(12 hours)

Wind Energy: Basic principle of Wind energy conversion, Wind data and Energy Estimation, Site selection considerations.

Types of Wind Turbines: Terminology, Impact of tower height, Maximum Rotor efficiency, Wind turbine generators, Average power in wind, Estimation of wind availability, performance evaluation.

UNIT-3

(12 hours)

Geothermal Energy: Estimation and nature of Geothermal Energy, geothermal sources and resources- hydrothermal, geo-pressured hot dry rock, magma, Geothermal energy - Application and Prospects of geothermal energy in India.

Ocean Energy: Ocean Thermal Energy Conversion (OTEC) System like open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India. Energy from tides, basic principle

of tidal power, single basin and double basin tidal power plants. Wave energy and power from wave, wave energy conversion devices.

UNIT-4

(12 hours)

Bio-Energy: Biomass as a source of energy, Classification of biomass, Biomass conversion process, Types of gasifiers, Briquetting, Gasification and combustion of biomass, Bio-methanation, biogas as a rural energy source, Environmental significance, Biomass production mechanism, Biogas plant and its components, Types of biogas plants, Design and construction features of Gasifiers.

Fuel Cell and MHD Systems: Fuel cell principle, classification, conversion efficiency, application. MHD Power Generation Principle, Open cycle and Closed cycle, Design problems and developments.

Recommended Readings

1. S. P. Sukhatme; Solar Energy - Principles of thermal collection and storage; second edition, Tata McGraw-Hill, New Delhi; 1996
2. G. D Rai; Non-Conventional Energy Sources; Khanna Publishers, 4e, New Delhi; 2005.
3. M. EL,Wakil; Power Plant Technology; McGraw Hill Book Company, New York; 1984.
4. B. Soreyson; Renewable Energy; Academic Press; 1989.
5. J. W. Twidell, A. D Weir; Renewable Energy Resources; ELBS Publication; 1986.
6. M. Kaltschmitt, W. Streicher, A. Wiese; Renewable Energy: Technology, Economics and Environment; Springer; 2006.
7. D. Y. Goswami, F. Kreith, J. F. Kreider; Principles of Solar Engineering; Taylor and Francis, Philadelphia; 2000.
8. D. D. Hall, R. P. Grover; Biomass: Regenerable Energy; John Wiley, New York; 1987.

List of Experiments:

At least eight assignments/mini-projects/case studies must be submitted by students within stipulated time.

ME 7.4.5 POWER PLANT ENGINEERING

Sub Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.5	Power Plant Engineering	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To develop an ability to apply knowledge of mathematics, science, and engineering.
2. To develop an ability to design a system, component, or process to meet desired needs within realistic constraints.
3. To develop an ability to identify, formulate, and solve engineering problems.
4. To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand design, erection and development of energy conversion plants.
2. Understand the Optimization of Energy Conversion plant with respect to the available resources.
3. Assess the scope of alternative erection of optimized, suitable plant at the location depending upon geographical conditions.

UNIT-1

(12 hours)

Power Generation: Global Scenario, Present status of power generation in India, in Goa, Role of private and governmental organizations, Load shedding, Carbon credits, Pitfalls in power reforms, concept of cascade efficiency, Introduction to the Sources of Energy – Resources and Development of Power in India.

Economics of Power Generation: Introduction, Cost of electric energy, Fixed and operating cost, Selection and Type of generation, Selection of generation equipment, Performance and operation characteristics of power plants and Tariff methods.

Steam Boilers: Fire tube and Water tube boiler, Low pressure and high pressure boilers, once through boiler, examples, and important features of HP boilers, Mountings and accessories. Layout of a modern HP boiler. Equivalent evaporation of boilers. Boiler performance. Boiler efficiency.

UNIT-2

(12 hours)

Thermal Power Plant: Introduction, General layout of modern power plant with different circuits, working of thermal power plant, coal classification, coal, ash and dust handling, selection of coal for Thermal Power Plant, FBC boilers, Rankine cycle with reheat and regeneration, cogeneration power plant.

Steam Condenser: Necessity of steam condenser, Classification, Cooling water requirements, Condenser efficiency, Vacuum efficiency, Cooling towers, air Leakage, Effects of Air Leakage on condenser performance.

Diesel Engine Power Plant: Plant Layout, Diesel Engine Power Plant Performance Analysis, application, selection of engine size, advantages & disadvantages of diesel power plant.

UNIT-3

(12 hours)

Nuclear Power Plant: Principles of nuclear energy, basic nuclear reactions, nuclear reactors-PWR, BWR, CANDU, Sodium graphite, fast breeder, homogeneous; gas cooled. Advantages and limitations, nuclear power station, waste disposal.

Gas Turbine Power Plant: Introduction, fuels, materials selection for GTPP, Brayton Cycle analysis, Thermal Efficiency, Work ratio, maximum & optimum pressure ratio, Actual cycle effect of operating variables on thermal efficiency, inter-cooling reheating, & regeneration cycle, Open, Closed & Semi Closed cycles Gas Turbine Plant, combined cycle plant.

Wind Power Plant: Introduction, wind availability measurement, types of wind machines, site selection, and wind power generation.

UNIT-4

(12 hours)

Solar Power Plant: Introduction, components, Types of Collectors & Solar Ponds, Low & High Temperature Solar Power Plant. Photovoltaic Power System, Heliostat Tidal, OTEC, geothermal, magneto hydrodynamics, fuel cell, hybrid power plants, Challenges in commercialization of Non-Conventional Power Plants.

Environmental impact due to power plants: Environmental aspects, introduction, constituents of atmosphere, different pollutants due to thermal power plants and their effects of human health, Environmental control of different pollutant such as particulate matter, Oxides of sulphur, nitrogen, global warming & green house effect, thermal pollution of water & its control. Noise pollution by power plants.

Recommended Readings:

1. E. I. Wakil; Power Plant Engineering; McGraw Hill Publications New Delhi; 1985.
2. P. K. Nag; Power Plant Engineering; McGraw Hill Publications New Delhi; 2017.
3. K. K. Ramalingam; Power Plant Engineering; SCITECH Publications Pvt. Ltd; 2015.
4. S. Domkundwar, S. Arora; Power Plant Engineering, Dhanpat Rai & Sons, New Delhi; 1975.
5. R. K. Rajput; Power Plant Engineering; Laxmi Publications New Delhi; 1995.
6. R. Yadav; Steam and Gas Turbines; Central Publishing House, Allahabad; 2011.
7. D. K. Chavan, G. K. Phatak, Power Plant Engineering, Standard Book House, New Delhi; 2013.
8. G. D. Rai; Non-Conventional Energy Sources; Khanna Publishers, Delhi; 2004.
9. S. P. Sukhatme; Solar Energy; Tata McGraw Hill Publications, New Delhi; 2008.

List of Experiments:

At least eight assignments/mini-projects/case studies must be submitted by students within stipulated time.

ME 7.4.6 DESIGN OF HEAT EXCHANGERS

Sub Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.6	Design of Heat Exchangers	3	--	2	3	100	25	-	-	25	150

Course Objectives:

1. To understand of the selection of Heat Exchangers,
2. To understand Their transfer processes, flow arrangements, fouling in Heat Exchangers,
3. To Design, analyze and evaluate the heat exchangers.
4. Applications of heat exchangers in Energy sector.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Select the appropriate heat exchanger.
2. Estimate fouling rates according to design conditions.
3. Perform sizing and rating of heat exchangers for complicated designs.
4. Design, analyze and evaluate heat exchangers.

UNIT-1

(12 hours)

Heat Exchangers: Classification according to transfer process, flow arrangement, number of fluids, surface compactness, and construction features. Tubular heat exchanger, plate type heat exchangers, extended surface heat exchangers, heat pipe, Regenerators.

Heat exchanger design methodology, assumption for heat transfer analysis, problem formulation, e-NTU method, P-NTU method, Mean temperature difference method.

UNIT-2

(12 hours)

Fouling of Heat Exchanger: Effects of fouling, categories of fouling, fundamental processes of fouling.

Double Pipe Heat Exchangers: Thermal and Hydraulic design of inner tube, Thermal and hydraulic analysis of Annulus, Total pressure drop.

Compact Heat Exchangers: Thermal and Hydraulic design of compact heat exchanger.

UNIT-3

(12 hours)

Shell and Tube Heat Exchangers: Tinker's, kern's, and Bell Delaware's methods, for thermal and hydraulic design of Shell and Tube heat exchangers.

Mechanical Design of Heat Exchangers: Design standards and codes, key terms in heat exchanger design, and thickness calculation for major components such as tube sheet, shell, tubes.

UNIT-4

(12 hours)

Improving Heat Exchanger Operation: Heat exchanger design for process industry, emerging trends in heat exchangers, Glass heat exchangers, applications and limitations.

Improving efficiency and effectiveness of heat exchangers, Miniaturization of heat exchangers, hybrid frame heat exchangers.

Recommended Readings:

1. R. K. Shah, D. P. Sekulic; Fundamentals of Heat Exchanger Design; John Wiley & Sons Inc.; 2003.
2. D. Q. Kern; Process Heat Transfer; McGraw Hill; 2001
3. H. Liu, S. Kakac; Heat Exchangers: Selection, Rating and Thermal Design; CRC Press; 1998.
4. A. P. Frass, M. N. Ozisik; Heat Exchanger Design; McGraw Hill; 1989.
5. N. Afgan, E.V. Schlinder; Heat Exchanger Design and Theory Source Book; CRC press; 2017.
6. T. Kuppan; Hand Book of Heat Exchanger Design; T.E.M.A. Standard, New York; 2017.
7. G. Walkers; Industrial Heat Exchangers-A Basic Guide; McGraw Hill; 1990.

List of Experiments:

At least eight assignments/mini-projects/case studies must be submitted by students within stipulated time.

ME 7.4.7 MODERN MANUFACTURING PRACTICES

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.7	Modern Manufacturing Practices	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand the need for modern manufacturing practices.
2. To study various Mechanical and Thermolectric Machining Processes
3. To understand the Electrochemical and Chemical Manufacturing Processes
4. To study Advance Welding and Die Casting Processes
5. To understand Advance Forming and Additive Manufacturing Processes.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand the basic principles of Mechanical, Thermolectric, Electrochemical, Chemical Manufacturing Processes, High Energy Rate Forming Processes.
2. Understand various equipments used in the various Mechanical, Thermolectric, Electrochemical, Chemical Manufacturing Processes and High Energy Rate Forming Processes.
3. Analyze the effect of process parameters in the various Mechanical, Thermolectric, Electrochemical, Chemical Manufacturing Processes and High Energy Rate Forming Processes.
4. Understand various aspects of Advance Forming and Additive Manufacturing Processes.

UNIT - 1

(12 Hours)

Introduction: Need for modern manufacturing practices. Process selection, classification, comparative study of different processes.

Mechanical Machining Processes: Ultrasonic Machining- Introduction, The machining system, Material removal process, Factors affecting material removal rate, Dimensional accuracy and surface quality, Applications. Water Jet Machining- Introduction, The machining system, Process parameters, Applications, Advantages and disadvantages. Abrasive Jet Machining-Introduction, Machining system, Material removal rate, Applications, Advantages and limitations of AJM. Abrasive Water Jet Machining-Introduction, The machining system, Process capabilities. Ice Jet Machining-Introduction, Process description. Magnetic Abrasive Finishing-Introduction, The machining system, Material removal process, Applications.

UNIT - 2

(12 Hours)

Thermolectric Machining Processes:

Electric Discharge Machining, Electric Discharge Grinding, Electric Discharge Diamond Grinding- Introduction, Material removal mechanism, Applications, Advantages and limitations.

Laser Beam Machining- Introduction, Material removal mechanism, Applications, Advantages and limitations.

Plasma Arc Machining- Introduction, Machining systems, Material removal rate, Accuracy and surface quality, Applications, Advantages and disadvantages.

Electron Beam Machining- Basic equipment and removal mechanism, Applications, Advantages and disadvantages.

Ion Beam Machining- Introduction, Material removal rate, Accuracy and surface effects, Applications.

UNIT - 3

(12 Hours)

Electrochemical and Chemical Manufacturing Processes:

Electrochemical Machining- Introduction, equipment, Basic working, Applications.

Electrochemical Grinding- Introduction, Material removal mechanism.

Electrochemical Drilling- Working principle, application.

Shaped Tube Electrolytic Machining- Working, process parameters, process capabilities, application, advantages.

Electrochemical De-burring- Working, Mechanism of de-burring, applications.

Chemical Milling- Process, advantages, limitations, applications.

Advance Welding and Die Casting:

Friction Stir Welding- Introduction, Tooling, Temperature distribution and resulting melt flow, application.

Advanced Die Casting- Vacuum Die casting and Squeeze Casting-process, advantages and applications.

UNIT - 4

(12 Hours)

Advance Forming Processes: High Energy Rate Forming Processes- Working principle, Advantages ,disadvantages and applications of Explosive forming processes, Propellant forming, Electro-Hydraulic forming, Electromagnetic forming, Spinning, Flow forming, Shear Spinning.

Additive Manufacturing Processes: Introduction, Liquid-Based Techniques- Process, advantages, disadvantages, and application of Stereolithography, Solid ground curing, Liquid thermal polymerization, Fused deposition modeling, Shape deposition manufacturing. Powder-Based Processes: Process, advantages, disadvantages, and application of Selective laser sintering, Laser engineered net shaping, Three-dimensional printing. Solid-Based Techniques: Process, advantages, disadvantages, and application of Solid foil polymerization, Laminated object modeling.

Recommended Readings:

1. H. El-Hofy; Advanced Machining Processes: Nontraditional and Hybrid Machining Process; McGraw Hill, New Delhi; 2005.
2. M. P. Groover; Fundamental of Modern Manufacturing: Materials, Processes and System; Wiley; 2009.
3. V. K. Jain; Advanced Machining Processes; Allied Publishers Pvt. Limited, New Delhi; 2005.
4. T. Jagadeesha; Non-Traditional Machining Processes; I. K. International Publishing House Pvt. Ltd; 2016.
5. A. Ghosh, A. K. Mallik; Manufacturing Science; Affiliated East-West Press Pvt. Ltd;

2010.

6. V. K. Jain; Micromanufacturing Processes; Taylor and Francis; 2012
7. J. A. McGeough; Micromachining of Engineering Materials; Marcel Dekker, New York ; 2002.
8. S. Kumar; Technology of Metal Forming Processes; Prentice Hall India Learning Private Limited;2008.
9. R. S. Mishra; M.W. Mahoney; Friction Stir welding and Processing; ASM International; 2007.
10. E. J. Vinarcik; High Integrity Die casting Processes; John Wiley and Sons; 2002.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.4.8 TOOL ENGINEERING

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.4.8	Tool Engineering	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Understand the importance of tool engineering.
2. Design jigs and fixtures.
3. Understand the applicability of Press tools, Dies and Moulds.
4. Understand different aspects of CNC machine tool design.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Select proper tool for given manufacturing operation.
2. Understand various locating and clamping devices.
3. Select and design jig and fixture for given simple component.
4. Classify and explain various press tools and press tools operations.
5. Select a die for producing a given simple component.

UNIT - 1

(12 Hours)

Introduction to Tool Design: Tooling, requirements of a tool designer, general tool design procedure. Design of Single point Cutting Tools, Design of single point lathe tool, Design of shank dimension using strength and rigidity considerations for rectangular, square and round cross section and selection of tool geometry. Solid type tool, brazed tip tool, long indexable inserts, throwaway indexable insert types and chip breakers.

Design of Multi Point Cutting Tool: Drill bit design of elements like back taper, web thickness, land width, margin, flute length and cross section and selection of tool geometry. Design of milling cutter - Design of elements like number of teeth and height circular pitch, body thickness, chamfer width, fillet radius and selection of tool geometry.

UNIT - 2

(12 Hours)

Design of Jigs: Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Principles of location - 3-2-1 and 4-1-1 types of locations, different types of locating elements. Clamping-Principles of clamping, types of clamping including power clamping devices. Drill jigs- Types, Drill bushes, simple exercises of designing jigs for given components.

Design of Fixtures: Fixture Design Turning fixtures, milling fixtures, grinding and broaching fixtures, indexing fixtures. Design of fixtures for simple components.

UNIT - 3

(12 Hours)

Design of Sheet Metal: Working of a power press and classification of presses. Components of a simple die, press tool operation, die accessories, shearing action in punch & die, clearance, shear on punch and die, Centre of pressure and problems, scrap

strip layout. Simple, progressive, compound, combination and inverted dies. Design problems on blanking and piercing dies for simple components.

Bending and Drawing: Bending dies – Introduction, bend allowance, spring back, edge bending die design. Drawing dies – Single action, double action and triple action dies, factors affecting drawing, drawing die design.

UNIT - 4

(12 Hours)

Die Casting Dies: Terminology- Core, cavity, sprue, slug, fixed and movable cores, finger cams, draft, ejector pins ejector plates, gate, goose nozzle, over-flow, platen, plunger, runner, vent, water-line etc. Types of Dies: Single cavity, multi cavity dies, combination dies, unit dies, advantages and disadvantages. Die casting dies, unit dies. advantages and disadvantages.

Injection Molding: Injection moulding machine and its elements, general configuration of a mould. 2 plate and 3 plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Introduction to compression, transfer, blow moulding, extrusion, forming and calendaring.

Tool Design for CNC machine tools: Tooling requirements for Numerical control systems, Fixture design for CNC machine tools. Cutting tools and Tool holding methods, Automatic tool changers and tool positioners, Tool presetting.

Recommended Readings:

1. B. J. Ranganath; Metal Cutting and Tool Design; Vikas Publishing House Pvt. Ltd.; New Delhi; 2009.
2. P. C. Sharma; Production Technology (Manufacturing Process); S. Chand Publishing; 2006.
3. P. C. Sharma; A Textbook of Machine Tools and Tool Design; S. Chand Publishing; 2005.
4. R. R. Kibbe, J. E. Neely, R. O. Meyer, W. T. White; Machine tool Practices; Pearson; 2010.
5. J. Nee; Fundamentals of Tool Design; Society of Manufacturing Engineers; PHI; 2010.
6. C. Donaldson, G. H. Lecain, V. C. Goold; Tool design; McGraw Hill Education; 2012.
7. L. E. Doyle; Tool Engineering: Analysis and Procedure; Prentice-Hall, 2007.
8. HMT; Production Technology; Tata McGraw-Hill Education, New Delhi; 2001.
9. Design Data: Data Book of Engineers; PSG College-Kalaikathir, Achchagam Coimbatore; 2012.
10. P. C. Sharma; A text book of Production Engineering; S. Chand Publishing; 1999

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.5.1 SIX SIGMA MANAGEMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.1	Six Sigma Management	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Exposing students to the fundamentals of Six Sigma methodology.
2. Exposing students to tools and techniques used in Six Sigma.
3. Building capability among students in mapping the organizational activities and problems in terms of six sigma framework.
4. Demonstrate ability to implement a structured approach for process, product or service improvement.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand the terminology and fundamentals of Six Sigma methodology.
2. Apply various tools and techniques used in Six Sigma.
3. Apply six sigma concepts and methodology to practical problems in industry.
4. Understand and Apply DMAIC and DFSS methodologies.

UNIT - 1

(12 Hours)

Overview of Six Sigma Management : Introduction, Successful applications of Six Sigma Management, Timeline for Six Sigma Management, Benefits of Six Sigma Management, Voice of the Process, Voice of the Customer, Non-technical and Technical Definition of Six Sigma, Terminologies in Six Sigma Management, Overview of PDCA.

Six Sigma Roles and Responsibilities: Champion, Master Black Belt, Black Belt, Green Belt, Yellow Belt, Process Owner.

Data Analysis: Measures of Central Tendency, Measures of Variation, Skewness, Kurtosis, Process capability calculation, and Measurement system analysis using gauge R&R.

UNIT - 2

(12 Hours)

Tools and Techniques used in Six Sigma: Process Map, Project charter, SIPOC diagram, Tree Diagram, Root Cause Analysis, Frequency distribution and Histogram, Run charts, Stem-and-leaf plots, Pareto diagrams, Cause and Effect Diagrams, Box Plots, Normal probability plots.

Quality Function Deployment, Failure Mode Effect Analysis - At least two case studies each.

UNIT - 3

(12 Hours)

Design of Experiments (DOE): Factorial designs: Introduction, Two-Factor factorial (2^2) design, Three-Factor Factorial (2^3) Design, ANOVA. Numericals on 2^2 and 2^3 factorial designs.

Taguchi Method: Taguchi philosophy, Loss function, Signal-to-Noise ratio, experimental design in Taguchi Method, Parameter design, Numericals on Taguchi Method.

UNIT - 4

(12 Hours)

DMAIC process: Define, Measure, Analyze, Improve, Control phases.

Case study on DMAIC - At least one each from manufacturing industry and service industry highlighting the use of tools and techniques used in each phase.

Design for Six Sigma (DFSS): Define, Measure, Analyze, Design, Verify phases.

Case study on DFSS - At least one each from manufacturing industry and service industry highlighting the use of tools and techniques used in each phase.

Recommended Readings:

1. H. S. Gitlow, D. M. Levine ; Six Sigma for Green Belts and Champions; Prentice Hall; First Edition; 2004.
2. A. Mitra; Fundamentals of Quality Control and Improvement; Wiley; Third edition; 2013.
3. D. C. Montgomery; Design and Analysis of Experiments; Wiley; Eighth Edition; 2013.
4. P. J. Ross; Taguchi techniques for Quality Engineering; McGraw Hill; Second Edition; 2005.
5. T. McCarty, L. Daniels, M. Bremer, P. Gupta; The Six Sigma Black Belt Handbook; McGraw Hill; 2010.
6. T. Allen; Introduction to Engineering Statistics and Six Sigma; Springer ; 2008.
7. J. ReVelle, J. Moran, C. Cox; The QFD Handbook; John Wiley and Sons; 1998.
8. T. Pyzdek; The Six Sigma Handbook; McGraw Hill; Eighth Edition; 2017.
9. G. R. Henderson; Six Sigma Quality Improvement with Minitab; Wiley; Second Edition; 2011.
10. A. M. Roderick, J. M. Matthew, B. N. Mohamed, R. Govindarajan, J. Z. Daniel; The Certified Six Sigma Green Belt Handbook; ASQ Quality Press; 2015.

List of Experiments:

At least eight assignments/practicals covering two assignments/practicals from each unit. Practical should have analysis performed on any one statistical software package such as MINITAB, SPSS, ISOGRAPH etc.

ME 7.5.2 MANAGEMENT INFORMATION SYSTEM

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.2	Management Information System	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand the importance Management Information Systems.
2. To understand basics of Structured Query Language.
3. To analyze systems and understand its design phases.
4. To understand the applicability of MIS in implementing Enterprise Management Systems.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand various types of MIS systems.
2. Select proper statements in SQL implementation.
3. Understand various DSS models.
4. Understand role of Artificial Intelligence and Expert Systems in MIS.
5. Understand basic aspects of Database Management System.
6. Understand Decision Making Process in implementing MIS.

UNIT - 1

(12 Hours)

Introduction: Introduction and importance of MIS, Computers and MIS, Organisational structure-basic model and its modifications, Information concepts, Information: A quality product, Classification of information, MIS and information concepts, Organizational behavior and MIS, Management and Decision making, Classification of information systems, Organizing Information System, Absorption of MIS in organizations. Evolution of Computer Hardware and software, Basics of networking topology, Open system interconnection (OSI) architecture, Intranet, Internet and extranet, Domain classification systems in internet, Packet switching, Latest trends in MIS.

UNIT - 2

(12 Hours)

Decision Making: Decision making concepts, Decision methods, tools and procedures, Decision making process, Systems, Types and natures of decisions, Methods for deciding decision alternatives, Organizational decision making, MIS and Decision making.

Decision Support Systems: Introduction, Characteristics, Types of DSS, Types of Tools/Models-Behavioral model, Management Science model, Operation research model, Examples of forecasting model, Budgeting model, Break even analysis model, Return on investment analysis model, Procedural model, Inventory control models, MIS and role of DSS.

Enterprise Management Systems: Introduction, Enterprise Resource Planning (ERP) System. ERP basic features, Benefits of ERP, ERP implementation, EMS and MIS.

UNIT - 3

(12 Hours)

Database Management Systems: Database Concept, Database Management System (DBMS), Database models, Data models, Entity Relation (E-R) Diagram, Database design, Conceptual model and physical model, Security in database environment, Definition and significance of Relational Database Management System (RDBMS).

Structured Query Language (SQL): Introduction, Using SQL to retrieve information from tables, Using relational and Boolean operators, Using separate operators in conditions, Summarizing data with aggregate functions, Formatting query output, Querying multiple tables at once, Entering, Deleting and changing field values, Creating tables.

UNIT- 4

(12 Hours)

Systems Analysis and Design: Introduction, Organizational context of system analysis, Role of system analyst, System Development Life Cycle (SDLC), Requirement Analysis, Requirement specifications, Diagramming techniques. Feasibility analysis, Feasibility report, Design and development phase, Implementation.

Artificial Intelligence and Expert Systems: Introduction, AI - Definitions, Components of AI, Expert Systems - Introduction, Architecture, Goal of expert system, Working, Stages in expert system development, Potential candidate for ES applications, Current application of ES, Advantages and limitations of expert system.

Recommended Readings:

1. S. Sadagopan; Management Information Systems; Prentice-Hall of India Pvt. Ltd.; 1997.
2. W. S. Jawadekar; Management Information Systems; Tata McGraw-Hill Publishing Company Ltd.; 2002.
3. G. Davis, M. Olson; Management Information Systems – Conceptual Foundations, Structure, Development; Tata McGraw-Hill Publishing Company Ltd.; 2009.
4. M. Gruber; Understanding SQL; John Wiley & Sons; 4e; 2000.
5. E. Oz; Management Information Systems; Thomson Press (India) Ltd; 6e; 2013.
6. D. P. Goyal; Management Information Systems: Managerial Perspective; Vikas Publishing; 2014.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. To solve a MIS case study on Manufacturing sector application.
2. To solve a MIS case study on Service sector application.
3. To construct and evaluate Data Flow Diagram for given system (Level 0).
4. To construct and evaluate Data Flow Diagram for given system (Level 1).
5. To create ER diagram.
6. To create and insert data for single/ multiple tables in DBMS.
7. To use basic select statement for single/ multiple tables in DBMS.
8. To use basic conditional statement for single/ multiple tables in DBMS.
9. To query multiple tables in DBMS.
10. To incorporate security in DBMS.
11. To study different types of Information system.

12. To study an Enterprise Resource Planning (ERP) case.

ME 7.5.3 SYSTEM MODELING AND SIMULATION

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.3	System Modeling and Simulation	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand fundamental concepts of system modeling and simulation.
2. To understand discrete and continuous simulation.
3. To learn about simulation languages and programming.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Differentiate between inferential statistics and simulation.
2. Compare between discrete and continuous simulation.
3. Apply knowledge to develop simulation programs for various applications.
4. Develop and run programs of queuing type in GPSS.

UNIT - 1

(12 Hours)

System models, System studies, System simulation – Concept, Need, Definition, Techniques, Inferential statistics and system simulation, Discrete and continuous system simulation, Random numbers – Need, Importance, Desirable properties, Generation, Inverse transformation method, Rejection method, Generation and application of random numbers with Bernoulli trial, Binomial, Geometric, Pascal, Exponential, Uniform, Normal, Weibull, Erlang distribution.,

UNIT - 2

(12 Hours)

Simulation approaches - Next event, Fixed time increment, Process oriented, Simulation of - Inventory system, Queuing system, Project network, Demand forecasting, Application of simulation for solving deterministic problems such as evaluation of definite integral, Estimating area of circle, Value of root, Value of imperfect square.

UNIT - 3

(12 Hours)

GPSS: Features, Introduction to various block and control statements such as GENERATE, ADVANCE, SEIZE, RELEASE, QUEUE, DEPART, ENTER, DEPART, TRANSFER, MARK, TABULATE, TERMINATE, SAVEVALUE, PRIORITY, ASSIGN, GATE, LOGIC, FUNCTION, START, RESET, JOB, SIMULATE, Standard numeric attributes, Modeling and simulation of various systems using GPSS.

UNIT - 4

(12 Hours)

Testing the random numbers for various distributions, Estimation of parameters, Analysis of output, Length of simulation, Effect of initial bias, Variance reduction techniques, Validation, Factors in selection of discrete simulation language, Classification of simulation languages, Features of SIMSCRIPT and SIMULA, Simulation of continuous systems, Continuous system simulation languages and their features.

Recommended Readings:

1. G. Gordon; System Simulation; Pearson Education, Inc.; 2e; 2015.
2. N. Deo; System Simulation with Digital Computer; Prentice-Hall of India Pvt. Ltd., 2013.
3. S. M. Ross; Simulation; Academic Press, Elsevier; 5e; 2013.

List of Experiments:

At least four simulation application programs to be developed in any programming language and at least four queuing type of application programs to be developed in GPSS.

ME 7.5.4 APPLIED OPERATIONS RESEARCH

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.4	Applied Operations Research	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To analyze real life decision making situations and develop the art of converting these situations into mathematical models
2. To understand the working principles of techniques to solve LPP models and solve differently styled LP problems
3. To study standard network analysis problems and apply solution techniques
4. To solve problems wherein the dynamic decisions are made in stages and consolidated to arrive at final decision
5. To understand the working of simulation technique and apply it to solve problems related to queuing and inventory systems

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Formulate a real life situation into a mathematical model
2. Select and apply appropriate technique to solve a linear programming model
3. Construct project networks and identify the critical path
4. Analyze a system's long term performance through simulation technique and use appropriate software for simulating standard situations
5. Recognize the need for a separate technique for specially structured linear programming models and accordingly apply the technique

UNIT-1

(12 hours)

Introduction: Management and decision making, Historical development of operations research, Models and principles of modeling, Techniques in operations research.

Linear Programming: Introduction, Formulation of linear programming problems (LPP), Assumptions and guidelines in solving LPP, Graphical method to solve LPP, Special cases.

Techniques to solve LPP: Simplex method, Analysis of special cases through simplex method, Big-M method, Two-phase method, Modified simplex method and Dual simplex method.

Duality and Sensitivity Analysis: Definition of a dual problem, Economic interpretation of dual, Primal-Dual computations, Post optimality analysis.

UNIT-2

(12 hours)

Integer Programming: Introduction, Branch & Bound technique, Gomory's cutting plane technique.

Specially Structured Linear Programmes: Transportation model, Formulation, Transportation algorithm – finding initial basic feasible solution using Northwest corner rule, Least cost cell and Vogel's approximation method. Optimizing using stepping stone method and MODI method.

Assignment model: Formulation, Hungarian algorithm.

UNIT-3

(12 hours)

Network Analysis: Introduction, scope, definitions, Minimal spanning tree problem, Shortest-Route problems, Maximal-flow problems, Project management – PERT/CPM.

Game Theory: Introduction, Two-person zero-sum game, saddle point, pure and mixed strategy, Dominance rule, graphical solution, formulation and solution as an LPP.

UNIT-4

(12 hours)

Dynamic Programming: Introduction, characteristics of dynamic programming, dynamic programming approach to Capital allocation problem, Knap-sack problem-additive and multiplicative, Travelling salesman problem, problem of dimensionality.

Queuing Theory: Introduction, general structure and performance measures of queuing system, Markovian model, Poisson-exponential single server infinite population and finite population model, cost analysis, determination of optimal service level, Poisson-exponential multiple servers in parallel infinite population model, queuing system, self-service system.

Recommended Readings:

1. A. Ravindran, D. Philips, J. J. Solberg; Operations Research: Principles and Practice; John Wiley & Sons Inc.; 2e; 2012.
2. R. Paneerselvam; Operations Research; Prentice Hall of India Private Ltd.; 2e; 2009
3. N. D. Vohra; Quantitative Techniques in Management; Tata McGraw-Hill Publishing Co. Ltd.; 2e; 2001.
4. S. D. Sharma; Operations Research: Theory; Methods and Applications; Kedar Nath; 2012.
5. J. K. Sharma; Operations Research; Laxmi Publications; 3e; 2009.
6. S. R. Yadav, A. K. Malik; Operations Research; Oxford University Press; 1e; 2014.
7. P. K. Gupta, D. S. Hira; Operations Research; S Chand; 5e; 1976
8. H. A. Taha; Operations Research: An Introduction; Pearson Education, Inc.; 9e; 2014.
9. F. S. Hillier, G. J. Lieberman; Introduction to Operations Research; Tata McGraw Hill; 8e; 2005.
10. G. Hadley; Linear Programming; Narosa Publishing House; 1990.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.5.5 INDUSTRIAL SAFETY AND ENVIRONMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.5	Industrial Safety and Environment	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand the concept and importance of industrial safety.
2. To appreciate the methods and mechanisms of ensuring industrial safety.
3. To understand the issues related to environmental protection.
4. To appreciate the ways of environmental protection.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand the concept of industrial safety.
2. Understand the importance of industrial safety.
3. Understand the causes and effects of industrial accidents.
4. Understand the causes and techniques of controlling industrial hazards.
5. Understand the procedure for planning for safety.
6. Understand the issues related to environmental protection.
7. Understand the ways of environmental protection.

UNIT - 1

(12 Hours)

Introduction to Industrial Safety: Concept of safety, Goals of safety engineering, Need for safety, Safety and productivity, employee participation in safety, safety and plant layout, safety and equipment design, safety and work environment.

Safety in Organization: objectives, functions, role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety Officer-responsibilities & authority. Safety committee-need, advantages.

Planning for Safety: Planning procedure, Safety policy-Elements of safety policy, formulation and implementation of safety policy.

Industrial Accidents: Definition of Accidents, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Nature, Causes, Classification. Accident costs, Measurement, Prevention. Investigation and analysis of accidents.

Safety Education: Training, Accident Report and Insurance Coverage, Personal Safety, Welfare provisions and role of Factory Inspector.

Accident Prevention: Method-Engineering, Education and Enforcement. Safety Education & Training. Communication- purpose, Barrier to communication. Role of Government Agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign.

Housekeeping: Responsibility of management and employees, Advantages of good housekeeping, 5S of housekeeping.

Safety in Material Handling: Manual Material Handling, effective methods of lifting, inbuilt safety in material handling equipments.

UNIT - 2

(12 Hours)

Industrial Hazards and Prevention: Types of industrial hazards: Chemical Hazards, Machine hazards, Fire hazard, prevention of fire, Fire detection and control, Extinguishers, Electrical hazards and safety requirements, Pressure vessel hazards, Safety precautions in boilers, Working in confined spaces, Working at heights, Noise and noise control, Dust control.

Hazard Identification techniques : Failure mode and effect analysis (FMEA) technique, Hazard and operability review technique, Human error analysis technique, Technique of operation review, fault tree analysis, risk analysis technique. Safety Audit.

Recognizing and Controlling Hazards: Engineering hazard control, work practice control, administrative control, and personal protective equipment.

First Aid, Artificial respiration.

UNIT - 3

(12 Hours)

Environmental Studies: Multidisciplinary nature of environmental studies. Definition, scope and importance. Need for public awareness.

Natural Resources: Renewable and nonrenewable resources. Natural resources and associated problems.

Forest Resources: Overexploitation, deforestation.

Water Resources: Use and over-utilization of surface and ground water, dams- benefits and problems.

Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources.

Food Resources: World food problems, changes caused by agriculture, effects of modern agriculture, fertilizer & pesticide problems.

Energy Resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources.

Land Resources: Land degradation, soil erosion and desertification.

Role of an individual in conservation natural resources. Equitable use of resources for sustainable life styles.

Ecosystems: Concept of an ecosystem. Types of ecosystems. Structure and function of an ecosystem.

UNIT - 4

(12 Hours)

Environmental Pollution: Definition. Causes, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards.

Solid Waste Management: Causes, effects and control measures of urban and industrial wastes. Role of individual in prevention of pollution.

Disaster Management: flood, earthquakes, cyclone and landslides.

Social Issues and the Environment: From unsustainable to sustainable development. Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics: Issues and possible solutions. Climatic change, global warming, acid rain, ozone layer depletion, nuclear accidents. Consumerism and waste products, Public awareness.

Recommended Readings:

1. S. Deswal, A. Deswal; A basic course in Environmental Studies; Dhanpat Rai and co.; 2008.
2. A. Parashar, P. Bansal; Industrial Safety and Environment; S. K. Kateriya and Sons; 2007.
3. Y. Anjaneyulu; Introduction to Environmental Science; B.S. Publications; 2005.
4. M. Basu, S. Xavier; Fundamentals of Environmental Studies; Cambridge University Press 2016.
5. S. Garg, R. Garg; Sewage Disposal and Air Pollution Engineering; Khanna Publishers; 1998.
6. L. M. Deshmukh; Industrial Safety Management; McGraw Hill Education (India) Pvt.Ltd. 2013.
7. S. Z. Mansdorf; Complete Manual of Industrial Safety; Prentice Hall; 1993.
8. A. N. Saxena; Safety & Good House-keeping; National Productivity Council,(NPC) New Delhi;1983.
9. K. T. Kulkarni; Introduction to Industrial safety; K. T. Kulkarni Publishers; 2002.
10. S. K. Dhameja; Environmental Engineering and Management; S. K. Kataria & Sons; 2004.
11. M. C. Sekhar, E. S. Rao; Environmental Science; The HI-TECH Publishers; 2004.
12. G. M. Masters; Introduction to Environmental Engineering and Science; Prentice Hall of India Pvt. Ltd; 2004.
13. R. W. King, J. Magid; Industrial hazard And Safety Handbook; Butterworths; 1980.
14. O. P. Khanna, A. Sarup; Industrial Engineering and Management; Dhanpat Rai Publications Ltd; 2015.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.5.6 INDUSTRIAL AUTOMATION AND PROCESS CONTROL

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.6	Industrial Automation and Process Control	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To impart knowledge of open and closed loop feedback control systems and their industrial application using various controllers
2. To impart knowledge of PLC , SCADA and Distributed Control System
3. To impart knowledge of image acquisition and processing for industrial automation applications
4. To impart knowledge of the various industrial communication systems and their interfacing in control systems.

Course Outcome:

After the successful completion of this course, the students will be able to:

1. Understand the concept of digital control system and analyze the discrete control system
2. Analyze the need for feed forward, intelligent and adaptive control.
3. Design and develop industrial PID controller.
4. Apply the working knowledge of PLC, SCADA and DCS in real time applications and develop a PLC programs for an automatic control systems.
5. Understand the various types of bus devices used for data communication in industry and apply the same for industrial communication systems..
6. Understand and apply knowledge of machine vision and image processing for Industrial automation and research applications.

UNIT - 1

(12 Hours)

Controllers: Review of PI, PD & PID controllers, controller tuning; Process reaction & ultimate cycle method, Brief overview of compensators.

Programmable Logic Controllers: Application of PLC for control; Pneumatic pistons, process motors, vibrating machine, conveyor motor, process tank, detection, sorting and packaging unit, PLC installation, troubleshooting and maintenance.

Smart Systems: Smart sensors and transmitters, examples, smart actuators.

UNIT - 2

(12 Hours)

Industrial Communication: Modbus, Profibus and Profinet for industrial communication, HMI; Types, visual structures of HMI, Data handling, applications, Sensor interface.

SCADA and DCS Distributed control systems: Distributed control systems (DCS): Definition, Hardware, Local Control architecture (LCU) languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept - case studies in DCS. SCADA.

UNIT - 3

(12 Hours)

Machine Vision: Vision system - human vision, disadvantages - machine vision, advantages - components and working principles of MVS - fundamental of Imaging - MVS specifications - design requirements - Human machine interfaces.

Image Analysis and Image Processing: Introduction to digital images - Image analysis - Basic, scalar, arithmetic - Image enhancement - Thresholding, Histogram, line profile, intensity measurement - Image processing - lookup tables(LUT), Morphology, spatial filters, Frequency domain processing - Blob analysis, Particle measurement, Dimension measurement - Edge detection, alignment, Pattern matching.

UNIT - 4

(12 Hours)

Case Studies of Control Systems in Automation: Flow Control systems, Hydraulic Control Systems, Pneumatic Control Systems, Electric Oven Control Systems, Thickness and Flatness Control System for Metal Rolling, Control of Metal Width and Thickness for Rolling Process, DC motor Position control system.

Internet for Measurement and Control

Measurements through Internet: Web based data acquisition - Monitoring of plant.

Parameters through Internet - Calibration of measuring instruments through Internet.

Internet based Control: Virtual laboratory, Internet of Things (IoT).

Recommended Readings:

1. M. Chidambaram; Computer Control of Processes; Narosa Publishing House; 2006.
2. C. Johnson; Process Control Instrumentation Technology; Pearson; 8e; 2006.
3. J. Prasad, M. N. Jayaswal, V. Priye; Instrumentation and Process Control; I K International Pvt Ltd; 1st Reprint; 2011.
4. S. K. Singh; Industrial Instrumentation and Control; McGraw Hill Publications; 2010.
5. H. R. Myler; Fundamentals of Machine Vision; Prentice Hall; 1999.
6. L. J. Galbiati; Image Processing Fundamentals; Prentice Hall; 1990.
7. R. Gonzalez, R. Woods; Digital Image Processing; Pearson; 3e; 2008.
8. R. Jain; Machine Vision; McGraw-Hill; 2016.
9. S. Jayaraman, T. Veerakumar, S. Esakkirajan; Digital Image Processing; McGraw Hill Education; 1st Edition; 2009.
10. J. Singh, M. Deswal; PLC and SCADA; Laxmi Publications Private Limited; First edition; 2016.
11. F. Klasen; Industrial Communication with Fieldbus and Ethernet; 2011.
12. D. Popovic, V. Bhatkar; Distributed Computer Control Systems in Industrial Automation; CRC Press; 1990.

13. M. Mitra, S. S. Gupta; Programmable Logic Controllers and Industrial Automation; 1e; 2008.
14. S. Soloman; Sensors and Control systems in Manufacturing; McGraw Hill Professional Publishing; 2e; 2009
15. W. Bolton; Mechatronics; Pearson Education India; 5e; 2011.
16. K. Krishnaswamy; Industrial Instrumentation; New Age International; 2010.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Design of PID Controller using MATLAB, Simulink etc.
2. Automatic PID tuning using MATLAB, etc
3. Design of compensator using MATLAB, etc
4. Real time image Acquisition and Processing with LABVIEW, etc
5. Image Processing with MATLAB, etc
6. Monitoring and control of Process parameters with SCADA
7. Sensor Interfacing with LABVIEW, etc
8. Control of motor using variable frequency drive
9. Two Exercises on Ladder Logic Programming using PLC (Arithmetic & Logical instructions)
10. Timer Block Programming using PLC
11. Counter Block Programming using PLC
12. PLC Interfacing with sensor
13. Interfacing of PLC with pneumatic system
14. Exercise on Industrial Communication (Profibus/Profinet/Modbus)
15. Design and development of a prototype of industrial automation/process control system.

ME 7.5.7 MICRO ELECTRO MECHANICAL SYSTEMS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.7	Micro Electro Mechanical Systems	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To provide an overview of Microsystems and their application in various branches of Engineering medical science and basic sciences.
2. To introduce sensors and actuators in Micro-domain.
3. To provide an insight into various microfabrication technologies.
4. To study modeling techniques for various applications.
5. To throw light upon integration and packaging of MEMS

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Select appropriate sensors and actuators for a given MEMS application.
2. Select a micro-fabrication technique for a specific MEMS fabrication process.
3. Develop a given MEMS system model.

UNIT - 1

(12 Hours)

Introduction to Micro and Smart Systems: Smart materials, Structures and systems, Components of a smart system, Microsystems, Micromachined transducers, Multi-disciplinary aspects, Applications areas, Commercial products.

Micro and Smart Devices and Systems: Definitions and salient features of sensors, actuators, and systems, Sensors: Silicon capacitive accelerometer, Piezo-resistive pressure sensor, Conductometric gas sensor, Fiber-optic gyroscope and surface-acoustic-wave based wireless strain sensor, Actuator: Silicon micro-mirror arrays, Piezo-electric based inkjet print-head, Electrostatic comb-drive and micromotor, Magnetic micro relay, Shape-memory-alloy based actuator, Electrothermal actuator System: Introduction to RF-MEMS, BIO-MEMS, high temperature MEMS and optical MEMS.

UNIT - 2

(12 Hours)

Fabrication Methods: Microfabrication Methods (VLSI Techniques) :Positive and Negative Photoresists, Bulk Micromachining, Surface Micromachining, Etching (Isotropic and Anisotropic), Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques, 3D High Aspect Ratio Techniques: LIGA, AMANDA, Microstereolithography, IH-Process, X-Ray Techniques, Ion-beam Lithography etc.

Scaling Laws in Miniaturization: Introduction to scaling, scaling in geometry, scaling in rigid body dynamics, scaling electrostatic forces, electromagnetic forces, electricity, scaling in fluid mechanics & heat transfer.

UNIT - 3

(12 Hours)

Modeling: Scaling issues, Elastic deformation and stress analysis of beams and plates, Residual stresses and stress gradients, Thermal loading, Heat transfer issues, Basic fluid issues Electrostatics. Couple delectro mechanics. Electromagnetic actuation. Capillary electro-phoresis. Piezoresistive modeling. Piezoelectric modeling. Megntostrictiveactuators. Microsystem Design: Thermomechanical stress analysis, Dynamic analysis, Design of a Silicon die for micropressure sensor, design of microfluidic network system: Fluid resistance in microchannels

UNIT - 4

(12 Hours)

Integration and Packaging of Micro Electro Mechanical Systems: Integration of microelectronics and micro devices at wafer and chip levels. Microelectronic packaging: wire and ball bounding, flipchip, Low-temperature-cofired-ceramic(LTCC) multi-chip-module technology, Microsystem packaging examples.

Case Studies on BEL pressure sensor, thermal cyler for DNA amplification, and active vibration.

Recommended Readings:

1. T. R. Hsu; MEMS and Microsystems: Design, Manufacture and Nanoscale Engineering; John Wiley & Sons;2e; 2008.
2. S. D. Senturia; Microsystem Design; Kluwer Academic Publishers, Boston. USA; 2001.
3. M. Bao; Analysis and Design Principles of MEMS Devices; Elsevier, Amsterdam; 1e; 2005.
4. V. Varadan, K.J. Vinoy, S. Gopalkrishnan; Design and Development Methodologies, Smart Material System and MEMS; Wiley; 2006.
5. M. J. Madou; Fundamentals of Microfabrication- The Science of Miniaturization; CRC press; 2002.
6. J. W. Garden, V. K. Varadan, O. O. Awadelkarim; Microsensors MEMS and Smart devices; John Wiley & Sons, Ltd.; 2001.
7. N. Mulaf, K. Williams; An Introduction to Microelectromechanical systems Engineering; Artech House Publishers; 2e; 2004.
8. N. Lobontiu, E. Garcia; Mechanics of Microelectromechanical systems; Kluwer Academic Publication; 2005.
9. S. Wolf, R. Tauber; Silicon Processing for the VLSI Era; Volume -1 Process Technology; Lattice Press; 2002.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Two exercises on simulation of MEMS sensors using a standard MEMS simulation software
2. Two exercises on simulation of MEMS actuators using a standard MEMS simulation software
3. Four exercises on Modeling of a MEMS system
4. Two exercises on Analysis of a MEMS system

Simulation should be performed using SUGAR, COMSOL, ANSYS, INTELLISUITE etc.

Analytical and Numerical Analysis should be performed using MATLAB, MATHEMATICA etc.

ME 7.5.8 COMPETITIVE MANUFACTURING MANAGEMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.5.8	Competitive Manufacturing Management	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To study the managerial perspectives and strategies of an organization.
2. To study the modeling of automated manufacturing systems and quality concepts
3. To understand the concept of value addition and lean manufacturing
4. To understand the concept of group technology and its application in cellular manufacturing and flexible manufacturing system

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Formulate managerial strategies and plan for its effective implementation
2. Apply total quality management concept in the industry
3. Group the parts based on design and manufacturing similarities
4. Design work cells in cellular manufacturing system

UNIT-1

(12 hours)

Strategic Management: An overview, company strategy, understanding a company: vision, mission, objectives, goals, strategies, and tactics, concept and process of strategic management, Strategic Business Unit (SBU). SWOT analysis, internal and external factors, classification of strategies, evaluation of strategic alternatives and strategy implementation.

Competitive Advantage: Evolution of manufacturing, modern development, mass production, the quality movement, continuous improvement, employee involvement, strategic planning for competitive advantage, problem solving improvement tools: histograms, flowcharts, diagrams, analysis, cause and effect analysis.

UNIT-2

(12 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.

Total Quality Management (TQM): Quality from producer's and customer's perspective, framework for managing total quality, Role of management, employee contribution, benchmarking, implementing TQM, barriers to TQM implementation.

Small-Lot Production: Lot sizing, lot-size reduction and its effects on competitive criteria, minimal lot size, need for buffer stock, small buffer stock, factors affecting buffer stock

UNIT-3

(12 hours)

Lean Manufacturing: Introduction, lean manufacturing principles, value added focus, sources of waste and its elimination, lean tools, kanban system, 5S, standardized work, lot sizing and setup reduction, methodology and techniques for setup reduction, continuous improvement, implementing lean-issues and challenges, benefits and limitations.

Facility Layout and Group Technology: Types of facility layouts, flexible flow lines, variety/volume trade-off, job shop and flow shop manufacturing, focused factories and group technology, product design, coding and classification schemes, cluster analysis.

UNIT-4

(12 hours)

Workcells and Cellular Manufacturing: Concepts, workstations, workers and machines, workcell output, multiple product families, linked workcells and subcells, workcell design, workcell capacity and cycle time, cost/capacity trade off analysis, productivity enhancement and quality control, manpower and equipment planning, implementing cellular manufacturing.

Flexible Manufacturing Systems– architecture of FMS – automated workpiece flow – automated assembly systems – deadlocks – performance measures.

Recommended Readings:

1. J. Nicholas; Competitive Manufacturing Management; Tata McGraw-Hill Edition; 2001.
2. N. Sing, D. Rajamani; Cellular Manufacturing Systems: Design, Planning & Control; 1e; Chapman & Hall; 1996.
3. R. G. Askin, C. R. Standridge; Modelling and Analysis of Manufacturing Systems; John Wiley & Sons. Inc; 1993.
4. M. P. Groover; Automation, Production Systems, and Computer-Integrated Manufacturing; 2e; Prentice-Hall of India Private Limited; 2001.
5. R. Pitts, D. Lei; Strategic Management: Building and Sustaining Competitive Advantage; 4e; South Western College Publishing; 2006.
6. Pearce; Strategic Management: Formulation, Implementation and Control; 8e; Mc-Graw Hill; 2003.
7. N. Viswanadham, Y. Narahari; Performance modeling of automated manufacturing systems, Prentice-Hall of India; 1e; 2008.
8. T. Altiok; Performance Analysis of Manufacturing Systems; Springer; 1997.
9. P. Brandimarte, A. Villa; Performance modeling of automated manufacturing systems; Prentice-Hall of India; 1996.
10. G. L. Curry, R. M. Feldman; Manufacturing systems modeling and analysis; Springer; 2011.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 7.6 PROJECT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 7.6	Project	--	--	4	--	--	--	--	--	25	25

Guidelines for Project:

- Project can be undertaken in-house or in an industry or in a research/service organization.
- Project batch will be preferably three to four, limited to six students.
- The project groups and title be preferably decided by the end of VIth semester.
- The Project Title/Synopsis should be submitted by the first fortnight of the term and approved by a designated departmental committee/Head of Department.
- The topic of the project may be in the area related to Mechanical Engineering involving investigation/analytical study/experimental work/fabrication/statistical study/simulation etc. The project should involve applications of concepts learnt during curriculum.
- The project work should be appropriately planned for VIIth and VIIIth semester.
- VIIth semester Project Report will preferably consist of Problem identification and Statement, Formulation of the objective and Scope of the study, Literature review, Methodology to be adopted, Part execution etc. Students shall submit project report to the department at the end of Semester.
- Students should present their work in three progress reviews (beginning, mid-sem and end-sem).

ME 8.1 COMPUTER INTEGRATED MANUFACTURING SYSTEMS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					Total
						Th	S	TW	P	O	
ME 8.1	Computer Integrated Manufacturing Systems	4	--	2	3	100	25	--	--	--	125

Course Objectives:

1. To understand fundamental concepts in CAM, CIMS, Robots and various automated production facilities.
2. To understand the basic concepts of automation and how it can be implemented in modern industry.
3. To learn the NC part programming, APT programming and Robot programming.
4. To understand fundamentals of Rapid Prototyping and its various processes.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Identify the main elements in Computer Integrated Manufacturing Systems.
2. Describe scope of NC, CNC, DNC, Adaptive control and Robotics in given industrial scenario.
3. Discuss applications of GT, CAPP, Automated material handling and storage systems, Automated inspection.
4. Apply knowledge to carry out NC, APT and robot programming.
5. Categorize and describe various Rapid Prototyping processes.

UNIT - 1

(16 Hours)

Introduction to CAM and CIMS, Automation in production systems, Numerical control (NC), NC part programming, Computer aided part programming, APT language, Computer controls in NC, Computer Numerical Control, Direct Numerical Control, Adaptive control machining systems.

UNIT - 2

(16 Hours)

Industrial Robotics, Robot technology, Robot kinematics – translation, rotation, coordinate system and its transformation, Robot arm dynamics, Robot programming and applications, Single station manufacturing cell, Group Technology (GT) and cellular manufacturing, Flexible Manufacturing Systems (FMS), Computer-Aided Process Planning (CAPP).

UNIT - 3

(16 Hours)

Automated material handling and storage systems, Automatic data capture, Automated production and assembly lines, Computer integrated production management system, Computer-process interfacing, Computer process control, Automated inspection, Lean production and agile manufacturing, Reverse Engineering, Web based manufacturing, Introduction to Industry 4.0, Product Life Cycle Management – introduction, phases,

emergence opportunities and applications.

UNIT - 4

(16 Hours)

Introduction to Rapid Prototyping (RP), RP procedure, Liquid-based RP processes, Solid-based RP processes, Powder-based RP processes, Design modeling for RP, Material selection for prototypes, Choosing a RP system, Applications of RP, Rapid Tool Production – Indirect and Direct methods.

Recommended Readings:

1. M. P. Groover; Automation, Production Systems and Computer-Integrated Manufacturing, Pearson Education Asia; 2e; 2001.
2. P. Nageswara Rao; CAD/CAM: Principles and Applications Tata McGraw-Hill Publishing Company Ltd., 2e, 2004.
3. M. P. Groover, Emory W. Zimmers, Jr.; CAD/CAM: Computer-Aided Design and Manufacturing; Prentice-Hall of India Pvt. Ltd.; 2000.
4. F. W. Liou; Rapid Prototyping and Engineering Applications; CRC Press; 2008.
5. T. Chang, R. A. Wysk, Hsu-Pin Wang; Computer Aided Manufacturing, Pearson Education Inc; 3e; 2013.
6. J. Stark; Product Lifecycle Management; Springer-Verlag London Limited; 2e; 2011.
7. D. T. Pham, S. S. Dimov; Rapid Manufacturing; Springer-Verlag London Limited; 2001.

List of Experiments:

At least eight NC part programs and/ or APT programs to be developed/ generated for machining the parts on lathe machine, drilling machine and milling machine using any CAM software(s).

ME 8.2 REFRIGERATION AND AIR-CONDITIONING

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.2	Refrigeration and Air-conditioning	4	--	2	3	100	25	--	25	--	150

Course Objectives:

1. To Study the basic principles and methods of refrigeration and air conditioning.
2. Study of various refrigeration cycles and evaluate performance using thermodynamic charts and/ or refrigerant property tables.
3. Comparative study of different refrigerants with respect to properties, applications and environmental issues.
4. Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
5. To study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Illustrate the fundamental principles of refrigeration and air conditioning system
2. Compute cooling capacity and coefficient of performance of refrigeration systems.
3. Identify and locate various components of the refrigeration and air conditioning system
4. Calculate cooling load for air conditioning systems used for various applications.

UNIT-1

(16 hours)

Introduction to Refrigeration: Methods of refrigeration, First and Second Law applied to refrigerating machines, Carnot refrigerator, Carnot heat pump, unit of refrigeration, Coefficient of Performance, Energy Efficiency Ratio (EER), BEE star rating.

Air Refrigeration Systems: Bell Coleman cycle, applications. Aircraft air refrigeration systems: Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, Reduced ambient, Regenerative air cooling system, Comparison of these systems based on DART rating.

Nonconventional Refrigeration Systems: Thermoelectric Refrigeration, Thermoacoustic Refrigeration, Vortex Tube Refrigeration, steam jet refrigeration.

UNIT-2

(16 hours)

Refrigerants- Classification of refrigerants, Desirable properties of refrigerants, environmental issues, Ozone depletion and global warming, ODP, GWP & LCCP,

selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes, refrigerant: recovery reclaims, recycle and recharge.

Simple Vapor Compression Refrigeration System: Simple vapor compression cycle, Effect of liquid sub-cooling & superheating, factors affecting the performance of VCRS, methods of improving, use of P-h charts, Mathematical analysis of VCRS. Actual Vapour Compression cycle.

Multistage Vapour Compression Refrigeration: Limitations of simple VCR cycle, Two stage VCR cycle with Water intercooler, flash intercooler & liquid sub-cooler.

UNIT-3

(16 hours)

Components of Refrigeration Systems:Types of condensers, evaporators, expansion devices and Compressors. Cooling tower: Types of cooling towers, tower approach, tower range, tower efficiency, tower losses, tower maintenance.

Cryogenics: Limitations of VCRS for production of low temperature, Cascade refrigeration system, Solid carbon dioxide or Dry ice, Liquefaction of gases, Liquefaction of air, Liquefaction of Hydrogen, Liquefaction of Helium, Applications of Cryogenics.

Vapor Absorption Refrigeration: Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Single and double effect, Electrolux refrigeration system. Solar VAR system.

UNIT-4

(16 hours)

Psychrometry: Need for air conditioning, Principle of Psychrometry, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, summer and Winter Air conditioning.

Human Comfort: Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone.

Design of Air Conditioning Systems: Different Heat sources,- Adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation, Introduction to Unitary Products viz. Room/Split and Packaged Air Conditioners, Introduction to recent developments viz. Variable Refrigerant Flow systems, VAV control systems, Inverter Units.

Recommended Readings:

1. C. P. Arora; Refrigeration and Air-conditioning; McGraw Hill Education, 3e;2008.
2. R. J. Dossat; Principles of Refrigeration; Wiley Eastern Publication; 2013.
3. W. F. Stoker, J. W. Jones; Refrigeration and Air-conditioning; McGraw-Hill Higher Education;1983.
4. P. Ananthanarayana; Basic Refrigeration and Air-conditioning; McGraw Hill Education; 4e ; 2013.
5. M. Prasad; Refrigeration and air-conditioning; New Age Int. (P) Ltd; 2e; 2013.
6. R. K. Rajput; Refrigeration and Air-conditioning; S. K. Kataria & Sons; 2013.
7. C. P. Arora; Modern Air-conditioning Practice; McGraw Hill Education; 3e; 2008.
8. ASHRAE Handbook of fundamentals of Refrigeration; 2014.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Performance Test on Domestic Refrigerator for evaluation of EER
2. Performance Test on Vapour Compression test rig
3. Performance Test on Vapour Absorption Refrigeration test rig
4. Performance evaluation of Air Conditioning system in recirculation type ducting.
5. Performance evaluation of Air Conditioning system in Open type ducting.
6. Performance Test on Ice Plant test rig
7. Performance Test on Heat Pump Test rig with capillary tube.
8. Performance Test on Heat Pump Test rig with solenoid valve.
9. Performance Test on water cooler test rig.
10. Estimation of Cooling load of Simple Air Conditioning system
11. Performance Test of cooling tower test rig.

ME 8.3.1 FINITE ELEMENT METHOD IN ENGINEERING

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th. Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.1	Finite Element Method in Engineering	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Understand the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems in Engineering.
2. Understand the mathematical and physical principles underlying the FEA
3. Demonstrate the ability to invoke appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems
4. Solve engineering problems using commercial software.

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Obtain and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
2. Apply mechanics of materials and machine design principles to provide preliminary results used for testing the reasonability of finite element results.
3. Interpret the results of finite element analysis and make an assessment of the results.

UNIT - 1

(12 Hours)

Introduction to Finite Element Method- general description of the method, Types of Elements, Steps involved, advantages, range of applications.

Basic Equations from Linear theory of Elasticity - Equilibrium Equations, Compatibility strain-displacement Equations, Generalized Hooke's Law: Constitution Laws for plane stress and plane strain problems, Strain Energy at a point under given state of stress.

Discrete systems- Generation of matrix displacement equations for 1-D bar element using direct and potential energy approach, Application to 1-D Fluid mechanics, 1-D heat transfer problem and 1-D Torsion.

UNIT - 2

(12 Hours)

Co-ordinate System – Global, local and natural co-ordinates, Convergence requirement on displacement field. Shape functions – Properties of shape functions, Development of shape functions for linear and higher order 1-D elements using generalized coordinates, Lagrange's interpolation function for higher order elements, shape functions in terms of natural co-ordinates and Cartesian co-ordinates for 2-D CST, shape functions for LST and 4-noded rectangular element. Brief introduction to Isoparametric element and its formulation - Jacobian matrix.

Variational Calculus - Functional, Euler- Lagrange's Equation, Approximate analytical method- Rayleigh-Ritz method; Applications to bars, trusses and beams. Rayleigh – Ritz - piecewise approach.

Solution of simultaneous equations using Gauss elimination, Cholesky's decomposition and Crout's factorization method.

UNIT - 3

(12 Hours)

Finite element Formulation of 2-D solid mechanics and 2-D heat transfer Problem - Generation of element level matrices and force vectors.

Weighted Residual methods – Strong formulation - Sub domain, least square, collocation method, Galerkin method-applications to bars and beam, weak formulation – Galerkin's piece wise formulation.

Numerical integration – Gauss Legendre Quadrature technique.

UNIT - 4

(12 Hours)

Stiffness matrix for a beam element. Hermite shape functions. Applications to determinate and indeterminate beams.

Structural Dynamics - Hamilton's principle, Free vibration analysis of bar, beam and shaft – consistent mass matrix –element equations, finding natural frequency and mode shapes.

Recommended Readings:

1. T. R. Chandrapatla, A. D. Belegundu; Introduction to Finite Element Method in Engineering; Prentice Hall of India; 2002.
2. S. S. Rao; Finite Element method in Engineering; Butterworth-Heinemann, 4e; 2005.
3. K. J. Bathe; Finite Element Procedure Prentice-Hall of India Pvt. New-Delhi; 1996
4. C. S. Krishnamoorthy; Finite Element Analysis, Theory and Programming; Tata McGraw-Hill Publishing Company Ltd. New Delhi; 2e; 2004.
5. C. S. Desai, J. F. Abel; Introduction to the Finite Element Method; CBS Publishers & Distributors; 2005.
6. S. Moaveni; Finite Element Analysis Theory and Application with ANSYS; Pearson Education Ltd.; 3e; 2008.
7. J. N. Reddy; An Introduction to the Finite Element Method; McGraw-Hill Company; 3e; 2005.

List of Experiments:

Exposure to FEM software, Solution of general field problems using any FEM software and solving for:

1. Bar subjected to axial loads
2. Two dimensional problems in structural analysis
3. Planar Trusses
4. One dimensional or Two dimensional Heat Transfer problems

ME 8.3.2 TRIBOLOGY

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.2	Tribology	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To introduce the fundamental principles of lubrication
2. To estimate and reduce friction and wear
3. To study different types of bearings used in engineering applications.
4. Develop ability to select / design bearings for required applications.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Apply the basic theories of friction, wear and lubrication to predict the tribological behavior of interfaces.
2. Characterize and model surface features and liquid lubricants for interfaces.
3. Analyze different types of bearings used in engineering applications.
4. Design/Select the type of bearing required for a given application.

UNIT - 1

(12 Hours)

Introduction: Meaning of Tribology, Friction, Lubrication and Wear.

Physical Properties of Lubricants: Oil viscosity and Viscosity Index, Viscosity Measurements, Viscosity of mixtures, Oil Viscosity classification, Thermal properties of lubricants, Lubricant impurities and contaminants.

Hydrostatic Bearings: Hydrostatic bearing analysis, Flat circular hydrostatic pad bearing: pressure distribution, lubricant flow, load capacity, friction torque, friction power loss, Generalized approach to hydrostatic bearing design.

UNIT - 2

(12 Hours)

Friction of Solids: Genesis of solid friction: Physical basis of the laws of friction, Adhesion, Junction growth. Static and Kinetic friction: Stick-slip effects and measurement of friction. Friction of non-metallic materials, Friction of rubbers and elastomers and friction of ceramics and cermets. Tribo-monitoring of friction.

Wear and Surface Damage: Introduction, Classification of wear, Wear maps. Mechanism of wear: Seizure, Melt wear, Oxidation dominated wear, Mechanical wear process, Running in Adhesive wear, Abrasive wear, Delamination wear, Fatigue wear in rolling contacts, Fretting and corrosive wear, Erosive wear, Third bodies & wear: Interfacial third bodies, Debris analysis. Tribo - monitoring of wear.

UNIT - 3

(12 Hours)

Hydrodynamic Bearings: Introduction, Reynolds equation, Simplifying assumptions, Equilibrium of an element, Continuity of flow in a column, Simplifications of Reynolds equation, Bearing Parameters predicted from Reynolds Equation.

Pad Bearings: Infinite linear Pad bearings, Infinite Rayleigh Step bearing, Finite Pad Bearings, Pivoted pad bearings.

Converging-Diverging Wedges: Bearing geometry, Pressure Distribution, Load Capacity.

Journal Bearings: Evaluation of main Parameters, Practical and Operation aspects of Journal bearings.

Aerostatic Bearings: Pressure distribution, Gas flow, Load capacity, Friction torque and Power loss. Hybrid bearings, stability of aerostatic bearings.

UNIT - 4

(12 Hours)

Elasto - Hydrodynamic Lubrication: Introduction, Contact Stresses, Contact between varying elastic bodies with varied geometry, Contact area, pressure, maximum deflection, and position of maximum shear stress. Elastohydrodynamic films, Effects contributing to the generation of Elastohydrodynamic films.

Applications of Tribology: Rolling Contact Bearings and Gears.

Bearing Materials: General requirements of bearing materials, types of bearing materials.

Recommended Readings:

1. B. C. Majumdar; Introduction to Tribology of Bearings; S. Chand & Co.; 2e; 2016.
2. S. K. Basu, S. N. Sengupta, B.B. Ahuja; Fundamentals of Tribology; Prentice Hall of India; 2010
3. G W. Stachowiak, A. W. Batchelor; Engineering Tribology; Butterworth Heinemann, 3e; 2005.
4. J. A. Williams; Engineering Tribology; Oxford University Press; 1995.
5. S. K. Srivatsava; Tribology in Industries; S Chand & Co.; 2001.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 8.3.3 PRODUCT DESIGN AND DEVELOPMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th. Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.3	Product Design and Development	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand need of new product design and its process.
2. To study product evolution through iterative process.
3. To understand the product life cycle.
4. To understand Aesthetic, Ergonomics and functionality of product.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Identify customers need through various methods.
2. Formulate problem based on need and market survey.
3. Prepare list of requirement as per the customers' needs.
4. Learn product design process.
5. Select material and understand product life cycle.

UNIT -1

(12 Hours)

Introduction to Product Design: Definition, Design Evolution, Design creativity, Design innovation, Factors of product design, Challenges of product design, Engineering design and Product Design, Generic product development process.

Product Development Process Tools: Team development, Product development Planning, Basic planning and Scheduling tools.

Product Aesthetics, Product Ergonomics, Product Functionality and Product life cycle.

UNIT - 2

(12 Hours)

Product Design Process: Product Planning, Identifying customer need, Product Specification, Concept Generation: Brainstorming, mind map, Concept Selection, Detail design, Computer Aided Design, prototyping and testing.

Product Design Methods: Creative and rational, clarifying objectives - the objective tree method, establishing functions- the function analysis method, setting requirements - the performance specification method, determining characteristics - the QFD method, generating alternatives - morphological chart method, evaluating alternatives - the weighted objective method, improving details - the value engineering method and design strategies.

UNIT - 3

(12 Hours)

Selection of Materials and Process: General requirement of early Material and Process Selection, Selection of Manufacturing processes, process Capabilities, Selection of materials, primary process/material Selection.

Ergonomics Consideration in Product Design: Human factors in Design, Anthropometry, Design of controls and display, man machine Interface. Computer Aided Product Design, Manufacturing and Management.

Product Prototyping: Types of Prototype, principles of prototyping, prototyping technologies.

UNIT - 4

(12 Hours)

Design for Manufacturing and Assembly: Introduction to DFM and DFA, Working of DFMA, Advantages of DFMA in Product Design

Design for Sustainability: Green design, Design for zero waste, Design for disassembly.

Economics of Product Development: Quantitative Analysis and Qualitative Analysis.

Patent and Intellectual Property: Introduction and types of Intellectual Property.

Recommended Readings:

1. K. T. Ulrich, S. D. Eppinger; Product Design and Development; McGraw Hill, 5e; 2011.
2. G. Dieter; Engineering Design - A materials and processing approach; McGraw Hill, NY; 2000.
3. O. Kevin, W. Kristin; Product Design: Techniques in reverse Engineering and New product Development; Prentice Hall of India; 1e; 2000.
4. A. K. Chitale, R. C. Gupta; Product Design and manufacturing; Prentice Hall of India; 6e; 2011.
5. P. Kumar; Product Design: Creativity, Concept and Usability; Prentice Hall of India; 2011
6. D. Norman; The Design of Everyday Things; Basic Books; 2e; 2013.
7. A. K. Agarwal; Business and Intellectual Property; Random House India Pvt. Ltd.; 2010.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 8.3.4 CRYOGENICS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.4	Cryogenics	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Study fundamental concepts of cryogenics
2. Study gas liquefaction and purification
3. Study operating in low temperature
4. Study Purification and separation system

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Explain historical developments in cryogenic systems
2. Describe gas liquefaction and purification systems/methods
3. Analyze system parameters and performance.
4. Understand the development of recent applications of cryogenics.

UNIT-1

(12 hours)

Introduction to Cryogenic System: History, development & present state. Low temperature properties of materials-mechanical, thermal and electrical properties. Cryogenic fluids and their properties. Cryogenic temperature scale, Joule-Thompson effect. Review of solid and fluid properties at low temperature. Application of cryogenics in space, food processing, biology, medicine, electronics & tool industry. Cryogenic fluid storage and transfer.

UNIT-2

(12 hours)

Gas Liquefaction System: Introduction, Critical components of liquefaction system Liquefaction system for air simple Lindle-Hampson system, Claude system, Heylndt system, dual pressure, Kapitza Liquefaction system for Neon, hydrogen & helium. Gas liquefaction system. Comparision of liquefaction cycles.

UNIT-3

(12 hours)

Cryogenic Refrigeration System: Introduction, Classification of Cryo-coolers, Stirling cycle Cryo-refrigerators, Ideal cycle- working principle. Refrigerators using solids as working media. Magnetic refrigeration system. Importance of refrigerator effectiveness.. Various configurations of stirling cycle refrigerators. Gifford McMahan Cryo-refrigerator, Pulse tube refrigerator, Solvay cycle refrigerator, Vuillimier refrigerator. Cryogenic regenerators.

Design criteria for equipment associated with low temperature systems: heat exchangers, compressors and expanders.

UNIT-4

(12 hours)

Purification and Separation System: Ideal work required for separation of gas mixture, Roul't's law, principle of gas separation, Linde single column air separation system, Linde double column separation system. Argon and neon separation system.

Various adsorbents, Salient features- Properties, determination of mass of adsorbents for the adsorption of gases, PSA and VSA adsorption systems.

Recommended Readings:

1. R. Barron; Cryogenics Systems; Oxford University Press; 1985.
2. R. F. Barron; Cryogenic systems; McGraw Hill; 1986.
3. Y. Mikulin; Theory and design of cryogenic systems; MIR Publications; 2002.
4. T. M. Flynn; Cryogenic Engineering; Marcel Dekker Inc., New York; 1997.
5. A. Bose, P. Sengupta; Cryogenic: Application and progress; Tata McGraw Hill; 1987.
6. K. D. Timmerhaus, T. M. Flynn; Cryogenic Process Engineering; Plenum Press, New York; 1989.
7. A. Arkherov; Theory and design of cryogenic systems; Mir Publication; 1981.

List of Experiments:

At least eight assignments/mini-projects/case studies must be submitted by students within stipulated time.

ME 8.3.5 ENERGY AUDIT AND MANAGEMENT

Sub Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.5	Energy Audit and Management	3	--	2	3	100	25	--	-	25	150

Course Objectives:

1. Study principles of energy management.
2. Study energy economics and auditing.
3. Study electrical energy management.
4. Study cogeneration and waste heat recovery.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Summarize and understand need for energy management, economics and auditing.
2. Describe importance of and analyze efficiency in thermal and electrical utilities.
3. Assess need of waste heat recovery and cogeneration.
4. Understand importance of Energy management towards sustainable growth.

UNIT-1

(12 hours)

General Aspects of Energy Management: Current energy scenario: India and World, Current energy consumption pattern in global and Indian industry, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy and environment, Need of Renewable and energy efficiency.

Energy Auditing: Need of Energy Audit, Types of energy audit, Components of energy audit, Energy audit methodology, Instruments, equipment used in energy audit, Analysis and recommendations of energy audit - applications, Energy audit reporting, Energy audit software.

UNIT-2

(12 hours)

Energy Economics : Costing of Utilities - Determination of cost of steam, natural gas, compressed air and electricity. Financial Analysis Techniques - Simple payback, Time value of money, Net Present Value, Return on Investment, Internal Rate of Return, Risk and Sensitivity analysis.

Boiler Performance Calculations: Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities, Boiler performance.

UNIT-3

(12 hours)

Energy Efficiency in Thermal Utilities: Energy conservation in refrigeration and air conditioning system, compressed air system. Energy conservation in steam generation and supply system.

Cogeneration: Need for cogeneration, Principle of cogeneration, Technical options for cogeneration, Classifications of cogeneration systems, Factors influencing cogeneration choice. Important Technical parameters for cogeneration, Quality of Thermal Energy Needed, Prime-movers for cogeneration, Typical cogeneration performance parameters, relative merits of cogeneration systems, Case study.

Waste Heat Recovery: Classification, Advantages and applications, commercially viable waste heat recovery devices, saving potential.

UNIT-4

(12 hours)

Insulation: Materials of insulations form of insulations, desirable properties of insulations, economic thickness of insulation, Refractories.

Electrical Energy Management: Distribution and transformer losses. Electrical motors - types, efficiency and selection. Speed control, Energy efficient motors, Electricity Act 2003.

Lighting - Lamp types and their features, recommended illumination levels, lighting system energy efficiency.

Recommended Readings:

1. A. Chakrabarti; Energy engineering and management; Prentice Hall India, New Delhi; 2012.
2. A. Thumann, W. J. Younger; Handbook of Energy Audit; The Fairmont Press Inc., en; 2007.
3. W. C. Turner; Energy management Handbook; The Fairmont Press Inc., Georgia, 5e; 1993.
4. Y. A. Abbi, S. Jain; Handbook on Energy Audit and Environment management; TERI, New Delhi; 2006
5. A. L. Kohan; Boiler Operators Guide Fourth Edition; McGraw Hill; 1997.
6. M. Golusin, S. Dodic, S. Popov; Sustainable Energy Management; Academic Press; 2013.
7. P. R. Trivedi, K. R. Jolka; Energy Management; Commonwealth Publications, New Delhi; 2011.
8. Energy Performance assessment for equipment and Utility Systems Vol. 1 to 4, Bureau of Energy Efficiency, Government of India.
9. General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, Government of India.

List of Experiments:

At least eight assignments/mini-projects/case studies must be submitted by students within stipulated time.

ME 8.3.6 COMPUTATIONAL FLUID DYNAMICS

Sub Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.6	Computational Fluid Dynamics	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To model fluid / heat transfer problems and apply fundamental conservation principles.
2. To discretize the governing differential equations and domain by Finite Difference Method.
3. To solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.
4. To prepare the students for career in industry in CAE through use of software tools.
5. To prepare the students for research leading to higher studies.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Analyze and model fluid flow and heat transfer problems.
2. Generate high quality grids and interpret the correctness of numerical results with physics.
3. Use a CFD tool effectively for practical problems and research.
4. Understand the programming skills.

UNIT-1

(12 hours)

Introduction to CFD: CFD – a research and design tool, CFD as third dimension of engineering supplementing theory and experiment, Steps in CFD solution procedure, strengths and weakness of CFD, Flow modeling using control volume - finite and infinitesimal control volumes, Concept of substantial derivative, divergence of velocity, Basic governing equations in integral and differential forms – conservation of mass, momentum and energy, Physical interpretation of governing equations, Navier-Stoke's model and Euler's model of equations.

UNIT-2

(12 hours)

Basic Discretization Techniques: Introduction to grid generation, Types of grids, Need to discretize the domain and governing equations, Finite difference approximation using Taylor series for first order- Forward Difference Approximation, Backward Difference Approximation, Central difference Approximation and second order - based on 3 node, 4 node and 5 node points ,explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation using FTCS and Crank Nicholson's Method, Stability Criteria concept and physical interpretation, Thomas Tri-diagonal matrix solver.

UNIT-3

(12 hours)

Two Dimensional Steady and Unsteady Heat Conduction: Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method, Approach for irregular boundary for 2D heat conduction problems.

Convection: First order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation Convection – Diffusion: 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, stability criteria, upwind difference approach, 1 D transient convection-diffusion system.

UNIT-4

(12 hours)

Incompressible Fluid Flow: Solution of Navier-Stoke’s equation for incompressible flow using SIMPLE algorithms and its variation, Application to flow through pipe, Introduction to finite volume method.

CFD as Practical Approach: Introduction to any CFD tool, CFD Procedure, Physical Boundary condition types- no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initializing and solution control for the solver, Residuals. Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations, Flow inside a 2-D square lid driven cavity flow through the nozzle.

Recommended Readings:

1. J. D. Anderson; Computational Fluid Dynamics- The Basics with Applications; McGraw-Hill; 2017.
2. J. Tu, G.H. Yeoh, C. Liu; Computational Fluid Dynamics; A practical approach, Elsevier.
3. A. W. Date; Introduction to Computational Fluid Dynamics; Cambridge University Press, India;1st edition;2009.
4. P. S. Ghoshdastidar; Computer Simulation of Fluid flow and Heat transfer; Tata McGraw-Hill; 1998.
5. P. Bates; Computational Fluid Dynamics; Wiley India; 2005.
6. J. Tannehill, D. Anderson, R. Pletcher; Computational Fluid Mechanics and Heat transfer; CRC Press; 2012.
7. J. H. Ferziger, M. Peric; Computational Methods for Fluid Dynamics; 3e, Springer;2002.
8. O. Zikanov; Essential Computational Fluid Dynamics; Wiley India; 2010.

List of Experiments:

At least eight assignments/mini-projects/case studies/software-based simulation/ must be submitted by students within stipulated time.

ME 8.3.7 NANOTECHNOLOGY

Sub Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th. Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.7	Nanotechnology	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand the fundamentals of Nanotechnology
2. To give a general introduction to different classes of nanomaterials
3. To impart basic knowledge on various synthesis and characterization techniques involved in Nanotechnology
4. To be able to analyze structural and optical properties of nanostructured materials.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Explain the importance of reduction in materials dimensionality, and its relationship with materials properties.
2. Demonstrate a comprehensive understanding of processing, manufacturing/fabrication of nanomaterials and nanostructures.
3. Understand the state-of-the-art techniques used for the characterization of nanomaterials and nanostructures.
4. Understand basic mechanical, optical and electronic properties of nanomaterials, as well as their applications in various fields
5. Understand the societal impact, challenges and risks of nanotechnology

UNIT-1

(12 Hours)

Introduction: Introduction to nanosstructures and nanomaterials, Classification of nanomaterials, size effects, Interactions and Topology, Molecular Basics, Social impacts, Future Prospects.

Unique Properties of Nanomaterials: Microstructure and Defects in Nanocrystalline Materials, Effect of Nano-dimensions on Materials Behaviour and Properties.

UNIT-2

(12 Hours)

Synthesis of Nanomaterials - I: Nucleation and Growth of Nanoparticles, Synthesis of Metal Nanoparticles by Microemulsions, Sol-Gel Method, Template based methods, Self-Assembly, Langmuir-Blodgett Method, Lithography.

Synthesis of Nanomaterials- II: Bottom Up & Top-Down Approaches, High Energy Ball Milling, Melt Mixing, Laser Ablation, Laser Pyrolysis, Sputter Deposition- DC and RF Sputtering, Chemical Vapour Deposition, Atomic Layer Deposition, Molecular Beam Epitaxy and Other Techniques of fabrication.

UNIT-3

(12 Hours)

Special Nanomaterials and their Applications: Carbon Nanotubes (CNT), Spherical fullerenes, Semiconductor Quantum Dots, Polymer Nanocomposites

Characterization of Nanostructures and Nanomaterials: X-ray Diffraction (XRD), Small Angle X-ray Scattering (SAXS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunnelling Microscope (STM), Spectroscopic Techniques.

UNIT-4

(12 Hours)

Applications of Nanomaterials: Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS), Nanosensors, Structure and Engineering, Automotive Industry, Water Treatment and the Environment, Nano-medical Applications, Energy, Defence and Space Applications.

Concerns and Challenges of Nanotechnology: Environmental and health hazards of nanoparticles, Balancing of Risks.

Recommended Readings:

1. G. Gao; Nanostructures and Nanomaterials: Synthesis, properties & applications, Imperial College Press; 2004.
2. C. P. Poole Jr., F. J. Qwens; Introduction to Nanotechnology, John Wiley & Sons, Inc.; 2003.
3. J. F. Mongillo; Nanotechnology; Greenwood Press; 2007.
4. A. K. Bandyopadhyay; Nano Materials,; New Age Publishers; 2008.
5. S. K. Kulkarni; Nanotechnology: Principles and Practices; Springer International; 3e; 2015.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Synthesis and characterization of Gold/Silver Nanoparticles.
2. Nano (Soft) Lithography Using PDMS.
3. Synthesis of Iron Oxide Nanoparticle by gel combustion technique and to determine the particle size using X-Ray Diffraction Techniques.
4. Thin film preparation by spin coating technique and to find dislocation density and strain of given sample By XRD methods.
5. Fabrication of Porous Alumina or Anodized Alumina (AAO) Template.
6. Synthesis of Zinc Oxide semiconducting nanoparticle by co precipitation technique and to calculate the absorption coefficient & optical band gap using UV-Vis spectrometer.
7. Synthesis of aqueous ferrofluid by wet chemical methods and Peak analysis of IR Transmission spectrum using FTIR spectroscopy.
8. Preparation of nanoparticles by using Ball milling and determine the particle size using X-Ray Diffraction Techniques.
9. Chemical bath deposition - Dip coating and to calculate the absorption coefficient & optical bandgap using UV-Vis spectrometer.
10. Preparation and characterization of ceramic based nanocomposites.
11. Preparation and characterization of metal-polymer nanocomposites.

ME 8.3.8 FIBRE REINFORCED COMPOSITES

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.3.8	Fibre Reinforced Composites	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To acquire comprehensive information about the science of processing various composites using different processing methods
2. To get an overview of the principles involved in the mechanics of FRCs.
3. Be able to apply the elementary theories to various problems involving FRCs.
4. Understand theories of failure to FRCs under load.
5. Get an introduction to the design process pertaining to composite materials.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Classify composite materials, fibres and matrices
2. Select appropriate reinforcement, matrix material and composition for the formation of composites with specific properties.
3. Analyze the mechanical behaviour of FRC and thin composite lamina at elementary level
4. Select and design FRCs for various engineering applications

UNIT - 1

(12 Hours)

Introduction to Fibre Reinforced Composites: Definition, General characteristics, Advantages, Disadvantages and Applications of composites, Material Selection Criteria – matrix and fibre materials

Fibre Materials: Natural fibres, Glass fibres, Carbon Fibres, Aramid Fibres, Boron fibres, Ceramic Fibres and their manufacturing. Continuous monocrystalline filaments, Whiskers, Surface Modification of fibres.

Matrix Materials: Polymer matrices –Thermoplastic and thermosetting matrix materials - Unique Characteristics of Polymeric Solids, Creep and Stress Relaxation, Heat Deflection Temperature; Overview of metal & ceramic matrix materials.

Fillers and other additives, Incorporation of fibres into matrix – Prepregs, Sheet Moulding Compounds (SMC), resin impregnation; Calculation of fibre content, density, void content; Fibre architecture.

UNIT - 2

(12 Hours)

FRC Manufacturing: Fundamental concepts- Degree of Cure, Viscosity, Resin Flow, Consolidation, Gel-time Test, Shrinkage, Voids.

Typical Manufacturing processes: Hand Lay-Up Process, Spray-Up Process, Autoclave Moulding, Resin Transfer Moulding, Reaction Injection Moulding, Filament Winding, Pultrusion, Compression Moulding; Manufacturing Processes for Thermoplastic Matrix Composites.

Machining and Joining of FRC: Cutting and trimming – Water jet cutting, Laser cutting; Joining Techniques - Mechanical joints, Adhesively Bonded Joints.

UNIT - 3

(12 Hours)

Quality Inspection Methods: Raw Materials, Cure Cycle Monitoring, Cured Composite Part - Radiography, Ultrasonic, Acoustic Emission, Acousto-Ultrasonic, Thermography

Mechanics of FRC: Fiber-Matrix Interactions in a Unidirectional Lamina, Longitudinal and Transverse Loading of Unidirectional Continuous and Discontinuous Fibres. Elastic Properties of a Lamina, Stress–Strain Relationships for a Thin Lamina, Compliance and Stiffness Matrices.

UNIT - 4

(12 Hours)

Characteristics of a Fiber-Reinforced Lamina – Fundamentals, Coordinate Axes, Notations, Stress and Strain Transformations in a Thin, Lamina under Plane Stress, Isotropic, Anisotropic, and Orthotropic Materials

Failure Prediction in a Unidirectional Lamina: Maximum Stress Theory and Tsai-Wu Failure Theory

Mechanical Properties and Testing of FRCs: Tensile Properties, Compressive Properties, Flexural Properties, Impact Properties, Fracture, Fatigue and Creep Properties of FRCs

Recycling of FRCs: Dealing with Wastes - Landfilling, Incineration, Recycling, Regrinding, Pyrolysis

Recommended Readings:

1. P. K. Mallick; Fiber Reinforced Composites; CRC Press; 3e; 2007.
2. B. D. Agarwal, L. J. Broutman, K. Chandrashekhara; Analysis and Performance of Fiber Composites, 3e; Wiley India; 2012.
3. I. M. Daniel, O. Ishai; Engineering Mechanics of Composite Materials; 2e; Oxford University Press; 2013.
4. G. Aklonis; Handbook of Composite Fabrication; Rapra Technology Ltd; 2001.
5. M. Balasubramanian; Composite materials and processing; CRC Press; 2014.
6. S. K. Mazumdar; Composites Manufacturing - Materials, Product, and Process Engineering; CRC Press; 2002.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Determination of Viscosity of a Thermosetting Resin.
2. Determination of Gel Time of a Thermosetting Resin.
3. Laminate Preparation by Hand Lay-Up Process using Polyester Resin.

4. Laminate Preparation by Hand Lay-Up Process using Epoxy Resin.
5. Tensile Testing of fibre reinforced composite specimen.
6. Flexural Testing of fibre reinforced composite specimen.
7. Impact test) of fibre reinforced composite specimen.
8. Determination of Peak Exotherm and Cure Time of Polyester Resin.
9. Determination of Heat Deflection Temperature.
10. Determination of Binder Solubility of Chopped Strand Mat.
11. Determination of Wetting Time of Chopped Strand Mat.
12. Laminate Preparation by Hand Lay-Up Process.
13. Bulk Molding Compound Preparation.
14. Compression Molding of Bulk Molding Compound.
15. Determination of Glass Fiber Content in FRP.
16. Exercises on 2-D Mechanics of composites using MATLAB, etc.

ME 8.4.1 SUPPLY CHAIN MANAGEMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.4.1	Supply Chain Management	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. The course employs a strategic structure that identifies and illustrates facilities, inventory, transportation, information, sourcing, and pricing as the key drivers of supply chain performance in order to help students understand what creates a competitive advantage.
2. The course provides guidelines for the students for implementing SCM initiatives to learn basically the "why, what and how" of supply chain management.
3. The course will help final year students, in revisiting the management policies being practiced in the industry where they will be assuming their office/get placed sooner.
4. The course conforms to the immediate requirements of aspirants for post graduate studies in Industrial Engineering, Mechanical Engineering and Management Colleges.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand key drivers of supply chain.
2. Understand how to deal with the interactions of business functions across organizations in the supply chain.
3. Understand Customer and Suppliers relationships.
4. Analyze facility location decisions.
5. Analyze case studies on supply chain elements and drivers.
6. Apply information systems to support collaboration and visibility of supply chains.
7. Create supply chain designs, which are aligned with business models for manufacturing and service companies.

UNIT - 1

(12 Hours)

Supply Chain Basics: History, Supply Chain Management, Manufacturing and Service Supply Chains, Product Life Cycle, Flow of Material Information and Funds, Push & Pull System, Mass Production, Mass Customization, Customization, Localization, Impact of Uncertainty on Supply chain, Responsive & Efficient Supply Chain, Zone of Strategic Fit, Total Profits Across Supply Chain.

Predictable Variability: Managing Supply & Demand, Forward Buying.

Supply Chain Performance Measures: Financial and Non Financial.

UNIT - 2

(12 Hours)

Facilities: Types of facilities, Role of Network Design in Supply Chain, Factors Influencing network Design Decisions, Framework for Facility Location Decisions, Gravity Location Model, Capacited Plant Allocation Model.

Inventory: Types of Inventory, EOQ, Quantity Discounts, CSL, Safety Inventory, Bullwhip Effect, Beer Game, Vendor Managed Inventory.

UNIT - 3

(12 Hours)

Transportation: Players in Transportation, Modes of Transportation, Design Options, Transportation- Inventory Tradeoff, Transportation-Responsiveness Tradeoff.

Distribution: Role of Distribution in Supply Chain, Factors Influencing Distribution Network Design, Design Options for a Distribution Network.

Information: Role of Information Technology in Supply Chain, Typical IT Solutions, E-Business, B2B, B2C, Logistics, Reverse Logistics, 3PL, 4PL.

UNIT - 4

(12 Hours)

Supplier Relationship Management: SRM Strategy, Critical Dimension of Relationship, Typology of Relationship, Relationship Path, Relationship Matrix.

Customer Relationship Management: CRM Strategy, Elements of Strategic Supply Chain.

Case Studies: Supplier Selection Using Multi Criteria Decision Making Techniques (AHP, TOPSIS, COPRAS), Activity Based Costing, Export/Import Business, Contract Agreements, Savings Matrix Method, Make or Buy Decision Making, Tourism and Mining Supply Chain in Goa.

Recommended Readings:

1. S. Chopra, P. Meindl, D. V. Kalra; Supply Chain Management – Strategy; Planning and Operation; Pearson Education; 6e; 2016.
2. R. P. Mohanty, S. G. Deshmukh; Supply chain Management - Theories & Practices; Biztantra; 2005.
3. J. Shah; Supply Chain Management Text and Cases; Pearson Education; 2009.
4. G. Raghuram, N. Rangaraj; Logistics and Supply Chain Management: Cases and Concepts; Macmillan India Ltd; New Delhi; 2000.
5. K. S. Bhat; Logistics Management; Himalaya Publishing house; 2009.
6. B. Hawkins, G. Bage; Making Contracts: Agreements to Buy or Supply - A Practical Guide; Kogan Page Limited; 1992.
7. U. K. Rai; Export Import and Logistic Management; PHI Learning; 2010.
8. C. R. Gopal; Export –Import Procedures, Documentation and Logistics; New Age International Publisher; 2006.
9. T. D. Chaudhuri, I. Ghosh; Application of Multi Criteria Decision Making in Management; Lambert Academy publishing; 2015.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 8.4.2 CORPORATE FINANCE

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.4.2	Corporate Finance	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To familiarize the students with the financial environment of business and financial markets.
2. To analyze financial statements – Balance sheet, Income Statement, Annual Report, Cash flow; to understand the Concept of Financial Ratios.
3. To understand the concept of Valuation – Time value of money, Valuation of securities, Risk and Return of single Asset and of a Portfolio.
4. To study Capital Budgeting Process, Different Investment Criteria; Rationale of Cash Flow and understand the Average Cost of Capital.
5. To study Sources of Long term Finance, Methods of Raising Long Term Finance; Concept of Working Capital and its requirements.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand the Fundamental principle of Finance, Financial decisions in a Firm, Organization of the Finance Function.
2. Analyze the Financial statements, Financial Ratios, Fund flow, Basis of Working Capital and Break-Even Analysis.
3. Understand Valuation Model and Perform the Valuation of Bond and Equity Valuation, Risk and Return of Asset and of a Portfolio.
4. Understand Capital Budgeting, WACC; Analyze Basic Capital Budgeting process and Cash flow.
5. Understand the Sources of Long term finance and Working Capital Requirements.

UNIT - 1

(12 Hours)

General Financial Environment: Financial decisions in a Firm, Goal of the Firm, Fundamental Principle of Finance, Organization of the Finance Function. Function's of Financial system, Financial Assets, Financial Markets and Market Returns, Financial Intermediaries, Regulatory Framework.

Financial Analysis and Planning: Financial Statements – Balance Sheet, Profit and Loss Account and Cash Flow, Analysis of Annual Report; Taxes, Financial Ratios – Liquidity ratios, Leverage ratios, Turnover ratios, Profitability ratios and Valuation ratios; Fund Flow Analysis, Sources and Uses of Working Capital, Cash flow statement, Break Even Analysis. Case Study.

UNIT - 2

(12 Hours)

Fundamental Valuation Concepts: Time Value of Money – Future Value of a Single amount, Future Value of an Annuity, Present Value of a Single Amount, Present Value of an Annuity; Basic Valuation Model, Bond and Equity Valuation; Risk and Return of a Single Asset, Portfolio of Assets, Risk and Return of a Portfolio.

UNIT - 3

(12 Hours)

Capital Budgeting: Introduction, Capital Budgeting Process, Investment Criteria: Discounting Criteria – Net Present Value, Benefit Cost Ratio and Internal Rate of Return; Non Discounting Criteria: Payback Period and Accounting Rate of Return.

Cash Flow: Rationale of Cash flow, Basic Principles of Cash flow Estimation, Elements of Cash flow estimation. Case study.

Cost of Capital: Introduction, Concept of Average Cost of Capital – WACC – its relevance and computation.

UNIT - 4

(12 Hours)

Sources of Long Term Financing: Introduction, Equity Capital, Internal Accruals, Preference Capital, Term loans, Debentures, Comparative Picture. Case Study.

Raising Long term Finance: Venture Capital, Initial Public Offer (IPO), Follow on Public Offer, Rights Issue, Private Placement, Case Study.

Working Capital: Working Capital Policy, Characteristics of Current Assets, Factors influencing Working Capital requirements, Levels of Current Assets, Current Assets Financing Policy, Operating Cycle and cash flow, Cash requirements for Working Capital, Case Study.

Recommended Readings:

1. R. Brealey, S. Myers, F. Allen, P. Mohanty; Principles of Corporate Finance; Tata McGraw Hill; 10e; 2012.
2. P. Chandra; Fundamentals of Financial Management; Tata McGraw Hill; 6e; 2006.
3. J. C. V. Horne, J. M. Wachowics, Jr.; Fundamentals of Financial Management; Prentice Hall of India; 13e; 2008.
4. M.Y. Khan, P. K. Jain; Financial Management; Tata McGraw Hill; 4e; 2004.
5. P. Chandra; Financial Management - Theory and Practice; Tata McGraw Hill; 8e; 2011.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 8.4.3 ENTREPRENEURSHIP DEVELOPMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/ week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.4.3	Entrepreneurship Development	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To equip them with requisite knowledge so that they can take up entrepreneurship as their career.
2. An understanding of qualities and requirements of an entrepreneur.
3. An ability to understand the requirements of Project identification, formulation and implementation.
4. An understanding of Break even analysis.
5. An understanding of the complexity of managing in a global world.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Explain the skills for project identification, formulation and implementation.
2. Explain the essential qualities and requirements of an entrepreneur.
3. Apply the concepts of Break even analysis.
4. Apply managerial concepts to solve complex problems related to global issues.

UNIT 1

(12 Hours)

Entrepreneurship Development: Meaning, objectives, scope & philosophy, type of entrepreneurs, factors affecting entrepreneurship, entrepreneurial qualities, major motives Influencing an Entrepreneur, need for promotion of entrepreneurship & small business, linkage between entrepreneurship and economic development, Entrepreneurship Support System.

Identification of Business Opportunities: SWOT Analysis, Environmental Screening-features, why, significance of environmental screening, Identification of business opportunities.

Small Scale Industry: Definition; Characteristics; Need and rationale: Objectives; Scope; role of SSI in Economic Development. Advantages of SSI, Steps to start an SSI – Government policy towards SSI; Different Policies of S.S.I.

UNIT 2

(12 Hours)

Project Identification: Assessment of viability, Formulation, Evaluation, Financing, Field-study and Collection of information, Preparation of project report, Demand analysis, Material balance and Output methods, Benefit cost analysis, Discounted cash flow, Internal rate of return and net present value methods. Guidelines by Planning Commission for Project report, Network Analysis, Errors in Project Report, Project Appraisal.

Project Planning and Control: The financial functions, cost of capital approach in project planning and control. Economic evaluation, risk analysis, capital expenditures. Profit planning and programming, planning cash flow, capital expenditure and operations. Control of financial flows.

UNIT 3

(12 Hours)

Financing and Accounting: Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, management of working Capital, Costing, Break Even Analysis. Preparation of balance sheets and assessment of economic viability, decision making, expected costs, planning and production control, quality control. Marketing, industrial relations. Sales and purchases, advertisement, wages and incentive, inventory control, preparation of financial reports, accounts and stores studies.

UNIT 4

(12 Hours)

Introduction to Production Management: Types of production systems, production planning and control, functions of production manager & materials management. Introduction to Human Resource Management: Manpower planning, recruitment, selection, placement & induction, training & development, compensation.

Laws concerning entrepreneur viz, partnership laws, business ownership, income taxes and workman compensation act.

Role of various national and state agencies which render assistance to small scale industries.

Recommended Readings:

1. V. Havinal; Management and Entrepreneurship; New Age International; 1e; 2011.
2. J. Forbat; Entrepreneurship; New Age International; 1e.; 2007.
3. P. Chandra; Fundamentals of Financial Management; 3rd Edition; Tata McGraw-Hill, New Delhi; 1995.
4. C. B. Gupta; Management: Theory and Practice; 19th Revised and Enlarged edition; Sultan Chand & Sons; 2017.
5. P. C. Tripathi, P. N. Reddy; Principles of Management; 2e; Tata McGraw Hill; 1991.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 8.4.4 ADVANCED OPTIMIZATION

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.4.4	Advanced Optimization	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand the advanced topics in linear programming like duality theory, parametric and goal programming.
2. To analyze the computational complexity of simplex method and Karmarkar interior point algorithm.
3. To analyze real life non linear situations and develop the art of converting these situations into mathematical models.
4. To understand the working principles of techniques to solve single variable and multi variable non-linear problems.
5. To understand the working and application of evolutionary algorithms.

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Compare the primal- dual relationship in linear programming problems.
2. Extend the application of sensitivity analysis to the effects of simultaneous changes in input data in linear programming problems.
3. Assess the computational complexity of algorithms.
4. Formulate a real life non-linear situation into a mathematical model.
5. Analyze different types of non-linear problems and apply appropriate solution technique.
6. Apply non conventional optimization techniques to solve non-linear optimization problems.

UNIT-1

(12 hours)

Duality Theory: Dual linear programs, comparison of primal and dual solutions, symmetric dual linear programs, economic interpretation of dual problem, asymmetric primal-dual problem.

Parametric Programming: Parametric cost problem and parametric right hand side problem.

Goal Programming: Formulation with competing objectives and solution algorithms.

UNIT-2

(12 hours)

Complexity of Algorithms: Introduction, space and time and computational complexity of algorithms, notations, performance measurement.

Interior Point Algorithm: Karmarkar algorithm and its comparison with simplex method

Probabilistic Inventory Models: Continuous review models, single period and multi period models.

UNIT-3

(12 hours)

Non-linear Optimization: Optimization in design, need. Concept of adequate, optimum and robust design. Formulation of design problem. Classification of design problems, classification of Optimization methods.

Single Variable Optimization: Classical technique, Bracketing and locating methods, Unrestricted search, Dichotomous search, Interval Halving method, Golden Section method, Fibonacci search. Interpolation methods: Bisection method, Secant method, Newton Raphson method.

Multi-variables Optimization without Constraints: Classical method, Powell's Conjugate direction method, Steepest Ascent Descent method, Newton's method and Simplex method.

UNIT-4

(12 hours)

Multi-variables Optimization with Constraints: KKT conditions, Lagrange's method, Cutting Plane method.

Genetic Algorithm in Non-linear Optimization: Introduction to genetic algorithm, evolution of species, chromosome coding, fitness function, genetic operators: selection, crossover and mutation. Application of genetic algorithm in solving simple non linear problems.

Evolutionary Algorithms: Introduction to other evolutionary algorithms like Simulated Annealing, Tabu search, Neural networks, Ant Colony Optimization.

Recommended Readings:

1. A. Ravindran, D. Philips, J. J. Solberg; Operations Research: Principles and Practice; John Wiley & Sons Inc.; 2e; 2012.
2. S. D. Sharma; Operations Research: Theory, Methods and Applications; Kedar Nath Ram Nath, Meerut; 2012.
3. J. K. Sharma; Operations Research; Laxmi Publications; 3e; 2009.
4. S. R. Yadav, A. K. Malik; Operations Research; Oxford University Press; 1e; 2014.
5. P. K. Gupta, D. S. Hira, Operations Research; S Chand; 5e; 1976.
6. H. A. Taha; Operations Research: An Introduction; Pearson Education Inc.; 9e; 2014.
7. H. Ellis, S. Sartaj, R. Sanguthevar; Computer Algorithms; Galgotia Publications Pvt. Ltd.; 2006.
8. S. N. Sivanandam, S. N. Deepa; Introduction to Genetic Algorithms; Springer; 1e; 2007.
9. D. Kalyanmoy; Optimization for Engineering Design: Algorithms and Examples; PHI Learning Pvt. Ltd.; 2e; 2012.
10. F. S. Hillier, G. J. Lieberman; Introduction to Operations Research; Tata McGraw Hill; 8e; 2005.
11. G. Hadley; Linear Programming; Narosa Publishing House; 1987.

List of Experiments:

At least eight assignments, two on each unit, must be submitted by students within stipulated time period.

ME 8.4.5 MAINTENANCE ENGINEERING AND MANAGEMENT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th.	S	TW	P	O	Total
ME 8.4.5	Maintenance Engineering and Management	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To introduce students various aspects of Maintenance and its related statistical analysis.
2. To develop awareness of Reliability, Availability and Maintainability strategies in the improvement of product and process quality.
3. To instill liking among student community, for techniques which are used in reduction of failures and downtime.
4. To enhance analytical abilities through the use of statistical approaches in Reliability, Availability and Maintainability.

Course Outcomes:

After the successful completion of this course, the students will be able to

1. Understand importance of Reliability, Availability and Maintainability and its role in downtime reduction.
2. Use measures of reliability, availability and maintainability on various time to failure models.
3. Understand various types of maintenance and its procedures.
4. Apply Reliability, Availability and Maintainability concepts in real world applications in industry.

UNIT-1

(12 hours)

Introduction: Maintenance Concept, Challenges, Objectives, Responsibilities of Maintenance Department, Types of Maintenance, Benefits and Effects of Maintenance, Maintenance Evaluation, Computers in Maintenance Economic Aspects of Maintenance, Organizational Structure for Maintenance, Lubricants and Maintenance, Maintenance Material Planning and Control, Manpower Planning for Maintenance, Environmental Impact of Maintenance, Categories of Maintenance Selective control.

Advanced Maintenance Systems: Introduction, Methodology and Benefits of Total Productive Maintenance, Reliability Centered Maintenance and Condition Based Maintenance.

UNIT-2

(12 hours)

Reliability Concepts: Review of Reliability Measures and failure distributions. Nonparametric methods for Ungrouped and Grouped Complete data. Probability Plotting: Exponential, Weibull, Normal and Lognormal distribution.

System Reliability: Series Configuration, Parallel Configuration, Complex Configuration, Star-Delta Configuration, Time dependent, Rare-event approximation, Minimal path and Cut sets. Standby Redundant systems: Perfect switching and Imperfect switching.

UNIT-3

(12 hours)

Reliability Testing: Product Testing, Reliability Life Testing, Test time calculations, Burn-in Testing, Accelerated Life Testing: Number of units on test, Accelerated Cycling, Constant-Stress Models.

State-Dependent Systems: Markov Analysis, Load-Sharing System, Standby Systems, Degraded Systems, Three-State Devices.

Failure Analysis, FMEA, System Safety and Fault Tree Analysis, Replacement Policies.

UNIT-4

(12 hours)

Maintainability: Analysis of downtime, The Repair-time distribution; Exponential, Lognormal, Reliability under Preventive Maintenance, State-Dependent Systems with repair.

Design for Maintainability: Maintenance Requirements, Design methods, Human Factors and Ergonomics, Maintenance and Spares Provisioning, Maintenance Prediction and Demonstration.

Availability: Concepts and Definitions, Exponential Availability model, System Availability: Introduction, Standby system availability, Stead-state system availability, Design trade-off analysis, Maintainability allocation.

Recommended Readings:

1. R. C. Mishra, K. Pathak; Maintenance Engineering and Management; Prentice Hall of India Pvt. Ltd.; 2e; 2012.
2. C. E. Ebeling; An Introduction to Reliability and Maintainability Engineering; Tata McGraw Hill; 2009.
3. S. S. Rao; Reliability Engineering, Pearson Education; 2016.
4. K. C. Kapur, L. R. Lamberson; Reliability in Engineering Design; Wiley India; 2011.

List of Experiments:

At least eight assignments, two on each unit must be submitted by students within stipulated time.

ME 8.4.6 FLUID POWER CONTROL

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th.	S	TW	P	O	Total
ME 8.4.6	Fluid Power Control	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Application of fluid mechanics and governing laws in hydraulic and pneumatic systems.
2. Study of working principle of various components used in hydraulic and pneumatic systems.
3. Selection of different components used in hydraulic and pneumatic systems.
4. Design of hydraulic and pneumatic circuits.
5. Industrial applications of hydraulic and pneumatic circuits.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand working principle of various components used for hydraulic & pneumatic systems.
2. Identify various components of hydraulic & pneumatic systems.
3. Select appropriate components required for hydraulic and pneumatic systems.
4. Design hydraulic and pneumatic system for industrial applications.
5. Understand industrial applications of hydraulic and pneumatic system.

UNIT 1

(12 hours)

Introduction to Fluid Power: advantages & application of fluid Power systems, Components of fluid power system, Types of fluid power control system, Environmental Issues.

Physical Properties of Hydraulic Fluids: Pascal's law, Bulk Modulus, Viscosity & Viscosity Index.

Energy and Power in Hydraulic Systems: Application of Pascal's Law, Conservation of Energy, The Continuity Equation, Bernoulli's Equation, Torricelli's theorem.

Hydraulic Conductors and Fittings: Conductor Sizing for Flow Rate Requirements, Pressure Rating of Conductors, Steel Pipes, Steel Tubing, Plastic Tubing, Flexible Hoses, Metric Steel Tubing.

UNIT 2

(12 hours)

Basics of Hydraulic Flow in Pipelines: Frictional losses in Laminar and Turbulent Flow, Losses in Valves and Fittings, Equivalent Length technique, Hydraulic Circuit Analysis.

Hydraulic Pumps: Pumping theory, Classification of pumps, Gear pumps, Vane pumps, Piston pumps, Pump Performance, Pump Selection, Pump Noise.

Hydraulic Actuators and Motors: Linear Hydraulic Actuators, Mechanics of Hydraulic Cylinders loadings, Limited Rotation Hydraulic Actuators, Gear Motors, Vane Motors, Piston Motors, Hydraulic Motor Performance.

Hydraulic Direction Control: Check Valves, Shuttle Valves, 2-Way, 3-Way and 4-Way Direction Control Valves, Direction Control Valve Actuation, Hydraulic Circuits, Specifications.

UNIT 3

(12 hours)

Hydraulic Pressure Control: Pressure Relief Valves, Unloading Valves, Pressure Reducing Valves, Sequence Valves, Counterbalance Valves, Brake Valves, Pressure Compensated Pumps, Specifications.

Hydraulic Flow Control: Flow Valve Control Valve types, Flow Coefficient, Circuits, Cushioned Cylinders, Flow Dividers, Specifications.

Ancillary Hydraulic Components: Accumulators, Intensifiers, Reservoirs, Filters, Seals and Bearing.

Maintenance of Hydraulic Systems: Maintaining and disposing of fluids, Wear of moving parts due to solid particle contamination of fluid, Problems caused by gases in hydraulic fluids, Temperature control, Trouble shooting Hydraulic systems, Safety considerations.

UNIT 4

(12 hours)

Pneumatics: Introduction, Gas laws, Gas Flow, Vacuum, Pneumatic Systems, Compressor Types, Compressor Sizing, Vacuum Pumps.

Pneumatic Components and circuits: Pneumatic Cylinders, Pneumatic Motors, Pneumatic Direction Control Valves, Pneumatic Flow Control Valves, Air Preparation, Air Distribution. Circuits for shuttle valve, AND valve, Quick exhaust valve, Meter-in & Meter-out, Pressure sequence valves.

Displacement diagrams.

Electropneumatics: Introduction, solenoids, switches, relays, PE converters, latching concept, circuits using electropneumatics.

Introduction to Cascading.

Recommended Readings:

1. A. Esposito; Fluid Power with Applications; Pearson; 5e; 2003.
2. J. L. Johnson, Introduction to Fluid Power, Delmar- Thomson Learning, Chennai, 2003.
3. S. Illango, V.Soundararajan; Introduction to Hydraulics and Pneumatics, Prentice Hall of India; 2e; 2013.
4. P. Rohner, Fluid Power and Logic Circuit Design, Macmillan, Hereford, United Kingdom, 1979.
5. J. Pippenger, T. Hicks, Industrial Hydraulics, McGraw Hill International Edition, Singapore, 1980.
6. T. Jagadeesha, T. Gowda; Fluid Power: Generation, Transmission, and Control, Wiley; 1e; 2013.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Experiments on hydraulic trainer.
2. Simulation of circuits using Automation studio software.
3. Simulation of circuits using FluidSIM Software.
4. Experiments on Pneumatic Trainer.
5. PLC based Fluid power experiments.
6. To extend, retract & stop a double acting cylinder.
7. To build and observe a regenerative circuit.
8. Build a sequence circuit to operate two cylinders in sequence.
9. To build a circuit with speed control.
10. To use a ladder program to control a power circuit.
11. To build a circuit using electropneumatics.
12. To build a circuit using electrohydraulics.
13. To build a pneumatic circuit using limit switches.
14. To build a circuit to study rotary actuator.
15. To estimate the pressure and flow rate at various points in the circuit.

ME 8.4.7 INDUSTRIAL ROBOTICS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.4.7	Industrial Robotics	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. To understand the structure ,classification & performance characteristics of a robot.
2. To study control systems and sensors used in robotics.
3. To introduce students to the forward & inverse kinematics of robots.
4. To throw light on programming in robotics.
5. To learn the concepts in machine vision, mobile robots and intelligent robots.

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Identify of key elements of industrial robotic system leading to correct choice of components for particular application.
2. Apply robot arm kinematics for designing robotic arm and it's simulation in appropriate software.
3. Apply and interface various sensors in robotic systems.
4. Apply the robot programming language for programming a pick and place robot.
5. Apply the concepts of machine vision and mobile robots for real time industrial robotic systems.

UNIT - 1

(12 Hours)

Basic Concepts in Robotics: Automation and robotics, robot anatomy, Basic structure of robots, DOF and degree of motion, joints and symbols, Work volume and envelope, Robot motions, resolution, accuracy and repeatability.

Classification and Structure of Robotic Systems: Point to point and continuous path systems. Grippers, Design of grippers.

Drives and Control Systems: Hydraulic and pneumatic systems, Control loop of robotic systems, Control approaches utilizing current and voltage amplifiers, Robot joint control design.

UNIT - 2

(12 Hours)

Robot Arm Kinematics: The direct kinematics problem, Denavit Hartenberg convention and its applications, Generation of motion commands, Trajectory planning, the inverse kinematics solution for 2 axis planar mechanisms, 3 axis spherical, and 6 axis manipulators.

Sensors in Robotics: Touch sensors, Force and torque sensors, Acoustic sensors, Slip sensors, Proximity & Range sensors.

UNIT - 3

(12 Hours)

Robot Programming: Lead through programming methods, Robot program as a path in space, Motion interpolation, WAIT, SIGNAL and DELAY commands., Branching, Programming the maker robot- The teach pendant, Moving the robot, Teaching Points, Teaching programs.

Robot Language : Robot language structure, constants, variables & other data objects, Motion commands, End effectors and sensor commands, Computations & operations, Program control and subroutines, Communications & data processing, Monitor mode commands, VAL II, Program for Pick and Place robot.

UNIT - 4

(12 Hours)

Machine Vision: Introduction, Sensing & digitizing function, Imaging devices, Lighting techniques, Image storage, Image processing and analysis, Image data reduction, segmentation, Feature extraction, Object recognition.

Mobile Robots: Introduction, Key issues for locomotion, Legged mobile robots, Leg configuration and stability, Types, Wheeled mobile robots, Wheel design.

Intelligent Robots: Introduction, Artificial Neural Networks, Genetic algorithm, Fuzzy Control.

Recommended Readings:

1. Y. Koran; Robotics for engineers; McGraw Hill Co.; 1985
2. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics Technology, Programming and Applications; Tata McGraw Hill Education; Special Indian; 2e; 2012.
3. K. S. Fu, R. C. Gonzalez, C. S. G. Lee; Robotics Control Sensing, Vision and Intelligence; McGraw Hill Book Co.; Tata McGraw Hill Education; 1e; 1987
4. R. Siegwart, I. R. Nourbakhsh; Introduction to Autonomous Mobile Robots; Prentice Hall of India; 2e; 2011.
5. S. Solomon; Sensors & control systems in manufacturing; McGraw Hill Education; 2e; 2009.
6. J. J. Craig; Introduction to Robotics, Mechanics and Control; Pearson Education Inc.; 3e; 2008.
7. R. K. Mittal; Robotics and Control; McGraw Hill Education; 1e; 2003.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Assemble mobile robot using microcontroller and various components.
2. Experiment on Pick and Place robot
3. Experiment on line follower and Obstacle avoidance robot
4. Two Exercises on simulation of robotic arm in sim-mechanics
5. Two experiments on Machine Vision

6. Exercise on Kinematics in Robotics
7. Two experiments in Virtual Robotics

ME 8.4.8 CONTROL SYSTEM ENGINEERING

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.4.8	Control System Engineering	3	--	2	3	100	25	--	--	25	150

Course Objectives:

1. Know the basic features, configurations and application of control systems.
2. Know various terminologies and definitions for the control systems.
3. To study mathematical system representations.
4. Know how to find time response from the transfer function.
5. Analyze the stability of a system from the transfer function

Course Outcomes:

After the successful completion of this course, the students will be able to:

1. Understand the benefits of using control systems.
2. Design and analyze of various control systems.
3. Describe quantitatively the transient response of first and second order systems.
4. Develop overall transfer function from the block diagram and signal flow graph.
5. Use root-locus design to meet stability and to find the transient response.

UNIT - 1

(12 Hours)

Feed Back Control Systems: Historical development, System representation, modern control systems.

Representation of Control Components: Operational notations. Mechanical components, electrical components, series and parallel law analogies, scale factors. Thermal systems, fluid systems.

Representation of Control Systems: Linearization of nonlinear functions, Linearization of operating curves, hydraulic systems, pneumatic systems, DC motors, AC motors, Block diagram algebra, speed control systems.

UNIT - 2

(12 Hours)

Steady State Operations: Steady state analysis, equilibrium, proportional control systems, integral control systems and their combination.

Laplace Transforms: Classical methods, Laplace transform method, transforms properties, initial conditions, general procedures, convolution integral, error coefficients.

UNIT - 3

(12 Hours)

Transient Response: Transformations. Complex conjugate zeros damping ratio and natural frequency. Computer solution transient response specification, general form of transient response to an external disturbance. Rouths stability criterion.

The Root-Locus Method: Significance of root loci. Construction of loci, general procedure. Loci equations of parameters.

UNIT - 4

(12 Hours)

System Representation: Signal flow graph, solution of state space equations transfer function, multi variable system.

Frequency Response Method: Logarithmic representation. Evaluation of gain, Polar plots, Correction between transient and frequency response.

Recommended Readings:

1. B. C. Kuo; Automatic Control Systems; Wiley; 9e; 2014.
2. K. Ogata; Modern Control Engineering, Pearson Education India; 5e; 2015.
3. J. Nagarath, M.Gopal; Control Systems Engineering, New Age International (P) Limited; 6e; Jan 2017.
4. F. H. Raven; Automatic Control Systems; Engineering McGraw Hill; 2015.

List of Experiments:

(At least eight experiments should be conducted from the list of experiments)

1. Generating standard test signals i.e. step, ramp, unit impulse on a simulator
2. Analysis of time response of second order system
3. Effect of P, PD, PI, PID Controller on a second order systems.
4. Plotting root locus of a given transfer function using a simulator
5. Temperature control using PID
6. Plotting phase magnitude plot of a given transfer function with a simulator.
7. Obtaining frequency response of a common emitter amplifier and plotting on a Bode plot.
8. Stability Analysis (Root locus, Bode, Nyquist) of Linear Time Invariant System.
9. Study of a PLL as a closed loop control system on a simulator.

Numerical Analysis should be performed using MATLAB, SCILAB, etc

ME 8.5 PROJECT

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Th Duration (Hrs)	Marks					
						Th	S	TW	P	O	Total
ME 8.5	Project	--	--	8	--	--	75	--	75	150	

Guidelines for Project:

- Students should present their work in two progress reviews (mid-sem and end-sem).
- VIIIth semester Project work being the concluding part of the Project, should preferably have details such as Statement of problem, Objective and Scope of the study, Literature review, Methodology, Results and Discussions, Conclusions and Future Scope, References etc.
- Students shall submit final project report to the department in the form of hard and soft copy at the end of the term.
- Term Work in project is a separate Head of Passing. The project work conducted and its report will be assessed under this Head.