SECOND YEAR: MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION

(RC 2016-17)

SEMESTER – III

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 3.1	Applied Thermodynamics - I	3	--	2	3	100	25	--	--	25	**150**
ME 3.2	Machine Drawing	2	--	3	4	100	25	25	--	--	**150**
ME 3.3	Fluid Mechanics	3	1	2	3	100	25	--	25	--	**150**
ME 3.4	Engineering Materials Science and Metallurgy	3	--	2	3	100	25	--	25	--	**150**
ME 3.5	Electrical Technology	3	1	2	3	100	25	--	--	--	**125**
ME 3.6	Engineering Mathematics and Numerical Techniques	4	--	--	3	100	25	--	--	--	**125**
TOTAL		**18**	**2**	**11**	**--**	**600**	**150**	**25**	**50**	**25**	**850**

A candidate is considered to have successfully fulfilled the requirement of a semester, provided he/she submits to the department a certified journal reporting the experiments conducted during the semester.

SECOND YEAR: MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION

(RC 2016-17)

SEMESTER – IV

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 4.1	Mechanics of Solids	4	1	--	3	100	25	--	--	25	**150**
ME 4.2	Analysis and Synthesis of Mechanisms	3	--	2	3	100	25	25	--	--	**150**
ME 4.3	Manufacturing Technology - I	3	--	2	3	100	25	--	25	--	**150**
ME 4.4	Digital Electronics and Microcontroller Applications	3	--	2	3	100	25	--	25	--	**150**
ME 4.5	Applied Thermodynamics - II	3	1	2	3	100	25	--	--	--	**125**
ME 4.6	Business Economics and Management	4	--	--	3	100	25	--	--	--	**125**
TOTAL		**20**	**2**	**8**	**--**	**600**	**150**	**25**	**50**	**25**	**850**

A candidate is considered to have successfully fulfilled the requirement of a semester, provided he/she submits to the department a certified journal reporting the experiments conducted during the semester.

THIRD YEAR: MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION

(RC 2016-17)

SEMESTER – V

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 5.1	Engineering Statistics	3	1	--	3	100	25	--	--	25	**150**
ME 5.2	Machine Design - I	3	--	2	3	100	25	25	--	--	**150**
ME 5.3	Energy Conversion	3	1	2	3	100	25	--	25	--	**150**
ME 5.4	Manufacturing Technology - II	3	--	2	3	100	25	--	25	--	**150**
ME 5.5	Dynamics of Machinery	3	--	2	3	100	25	--	--	--	**125**
ME 5.6	Engineering Measurements and Metrology	3	--	2	3	100	25	--	--	--	**125**
TOTAL		**18**	**2**	**10**	--	**600**	**150**	**25**	**50**	**25**	**850**

#A candidate is considered to have successfully fulfilled the requirement of a semester, provided he/she submits to the department a certified journal reporting the experiments conducted during the semester.

THIRD YEAR: MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION

(RC 2016-17)

SEMESTER – VI

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 6.1	Quality and Reliability	4	1	--	3	100	25	--	--	25	**150**
ME 6.2	Machine Design - II	3	--	2	3	100	25	25	--	--	**150**
ME 6.3	Gas Dynamics and Turbomachineries	3	1	2	3	100	25	--	25	--	**150**
ME 6.4	Mechanical Vibrations	3	--	2	3	100	25	--	25	--	**150**
ME 6.5	Mechatronics	3	--	2	3	100	25	--	--	--	**125**
ME 6.6	Automobile Engineering	3	1	--	3	100	25	--	--	--	**125**
TOTAL		**19**	**3**	**8**	**--**	**600**	**150**	**25**	**50**	**25**	**850**

A candidate is considered to have successfully fulfilled the requirement of a semester, provided he/she submits to the department a certified journal reporting the experiments conducted during the semester.

FINAL YEAR: MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION

(RC 2016-17)

SEMESTER – VII

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**
ME 7.2	Industrial Engineering and Operations Management	4	1	--	3	100	25	--	--	--	**125**
ME 7.3	CAD and FEA	3	1	2	3	100	25	--	25	--	**150**
ME 7.4	Elective - I	3	--	2	3	100	25	--	--	25	**150**
ME 7.5	Elective - II	3	--	2	3	100	25	--	--	25	**150**
ME 7.6	Project	--	--	4	--	--	--	--	--	25	**25**
TOTAL		**16**	**2**	**12**	**--**	**500**	**125**	**--**	**25**	**75**	**725**

#A candidate is considered to have successfully fulfilled the requirement of a semester, provided he/she submits to the department a certified journal reporting the experiments conducted during the semester.

List of Electives

Subject Code	Elective - I	Subject Code	Elective - II
ME 7.4.1	Advanced Mechanics of Solids	ME 7.5.1	Six Sigma Management
ME 7.4.2	Advanced Analysis and Synthesis of Mechanism	ME 7.5.2	Management Information System
ME 7.4.3	Vibration and Noise control	ME 7.5.3	System Modeling and Simulation
ME 7.4.4	Alternate Energy Sources	ME 7.5.4	Applied Operations Research
ME 7.4.5	Power Plant Engineering	ME 7.5.5	Industrial Safety and Environment
ME 7.4.6	Design of Heat Exchangers	ME 7.5.6	Industrial Automation and Process Control
ME 7.4.7	Modern Manufacturing Practices	ME 7.5.7	Micro Electro Mechanical Systems
ME 7.4.8	Tool Engineering	ME 7.5.8	Competitive Manufacturing Management

FINAL YEAR: MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND EXAMINATION

(RC 2016-17)

SEMESTER – VIII

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 8.1	Computer Integrated Manufacturing Systems	4	--	2	3	100	25	--	--	--	**125**
ME 8.2	Refrigeration and Air-Conditioning	4	--	2	3	100	25	--	25	--	**150**
ME 8.3	Elective - III	3	--	2	3	100	25	--	--	25	**150**
ME 8.4	Elective - IV	3	--	2	3	100	25	--	--	25	**150**
ME 8.5	Project*	--	--	8	--	--	--	75	--	75	**150**
TOTAL		**14**	**--**	**16**	**--**	**400**	**100**	**75**	**25**	**125**	**725**

*Term Work in Project is a separate Head of Passing

A candidate is considered to have successfully fulfilled the requirement of a semester, provided he/she submits to the department a certified journal reporting the experiments conducted during the semester.

List of Electives

Subject Code	Elective - III	Subject Code	Elective - IV
ME 8.3.1	Finite Element Method in Engineering	ME 8.4.1	Supply Chain Management
ME 8.3.2	Tribology	ME 8.4.2	Corporate Finance
ME 8.3.3	Product Design and Development	ME 8.4.3	Entrepreneurship Development
ME 8.3.4	Cryogenics	ME 8.4.4	Advanced Optimization
ME 8.3.5	Energy Audit and Management	ME 8.4.5	Maintenance Engineering and Management
ME 8.3.6	Computational Fluid Dynamics	ME 8.4.6	Fluid Power Control
ME 8.3.7	Nanotechnology	ME 8.4.7	Industrial Robotics
ME 8.3.8	Fibre Reinforced Composites	ME 8.4.8	Control System Engineering

ME 5.1 ENGINEERING STATISTICS

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 5.1	Engineering Statistics	3	1	--	3	100	25	--	--	25	**150**

Course Objectives:

1. To understand the pattern of randomness found in real life situations and the necessity of modeling the situations
2. To study widely used discrete and continuous distribution along with their applications.
3. To estimate the unknown parameters of the population and implement hypothesis testing
4. To understand advanced statistical analysis through goodness of fit, ANOVA and regression.

Course Outcomes:

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

1. Understand the randomness in real life situations and draw meaningful conclusions.
2. Compute point and interval estimates of parameters of population.
3. Perform hypothesis testing on the derived conclusions about population parameters.
4. Perform statistical analysis using goodness of fit, ANOVA and regression.

UNIT-1 (12 hours)

Probability Preliminary: Review of Set theory, Introduction to Probability, definition, Sample Space, Events, Conditional Probability, Theorem on total probability, Bayes' theorem.

Random Variable: Introduction, Discrete and Continuous, Characteristics-Mean, Variance and distribution function.

Function of One Dimensional Random Variable: Discrete and continuous case, E and V-operations with approximations. Moment-Generating function.

Discrete Probability distribution: Bernoulli trial, Binomial, Geometric, Poisson, Hyper-Geometric, Uniform. Mean, variance and distribution function, important properties, approximations and applications.

UNIT-2 (12 hours)

Continuous Probability Distribution: Uniform, Exponential, Normal, Lognormal and Weibull distribution. Mean, variance and distribution function, important properties, approximations and applications.

Statistic and Sampling Distribution: Population and the Sample, Statistic, Sampling distributions- Normal, Student's t-distribution, Chi-square and F- distributions.

UNIT-3 (12 hours)

Parameter Estimation: Point Estimation -Definition, unbiased estimator, standard error, method of maximum likelihood and methods of moments. Parameter estimation of standard distributions- Bernoulli, Binomial, Geometric, Exponential and Normal.

Parameter Estimation: Confidence Interval Estimation- Concept, Confidence interval on mean and difference in means of single and two normal population, variance known and unknown, Confidence interval on variance of normal population and on the ratio of variances of two normal distributions, Error and selection of sample size.

Tests of Hypotheses: Introduction, Type I and type II errors, significance level and power of the test, Test of hypotheses - on mean of single normal population and equality of two means of two normal populations with variance(s) known and unknown, on variance of single normal population and variances of two normal populations, choice of sample size.

UNIT-4 (12 hours)

Goodness of Fit Test: Chi-square test- Introduction, concept, algorithm for testing discrete and continuous distributions, P-value, Test for Independence.

Analysis of Variance (ANOVA): Concept, one way and two-way classification, statistical analysis on fixed effect model.

Simple Linear Regression: Empirical Models, Simple Linear Regression Concept, Hypothesis Tests: Use of t-test, ANOVA approach to test significance of regression, Model Adequacy: Residual analysis and Lack-of-fit.

Recommended Readings:

1. D. C. Montgomery, C. G. Runger, Applied Statistics and Probability for Engineers, 6th Edition, n Wiley India, 2016.
2. D. C. Montgomery, G. C. Runger, N. F. Hubele; Engineering Statistics, Wiley India; 5th Edition; 2013.
3. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists,9th Edition, Pearson Education India, 2013.
4. R. A. Johnson, Probability and Statistics for Engineers, 8e, Prentice Hall of India, 2011.
5. T. Veerarajan; Probability, Statistics and Random Processes, 3e, Tata McGraw Hill India; 2017.
6. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010.
7. A. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015

Assignments:

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

ME 5.2 MACHINE DESIGN – I

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 5.2	Machine Design – I	3	--	2	3	100	25	25	--	--	**150**

Course Objectives:

1. The student will achieve an understanding of the design process in mechanical engineering and will be able to correlate design with manufacturing
2. The student shall learn to select the materials for various applications depending on factors like loading, service conditions, cost etc.
3. The student shall appreciate the various modes of failure in a machine component and use the appropriate theories of failure to carry out the stress analysis and design the components.
4. The student shall understand and be able to design the various types of components such as fasteners, shafts, couplings etc.
5. The student shall be able to decide and design the temporary and permanent joints used in joining machine components.

Course Outcomes:

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

1. Analyze the stresses and strains in mechanical components and be able to understand and identify the failure modes in machine components.
2. Design machine elements and components for static as well as fatigue-loading.
3. Prepare the production drawings of the components designed for shop floor use.
4. Choose the parameters that will optimize the design for mechanical systems.

UNIT - 1 (12 Hours)

Introduction to Design Process: Process of Machine Design, Design considerations in machine parts, Use of standard codes, Factor of Safety, Preferred Numbers and Preferred Series.

Static Considerations in Design: Design of simple parts subjected to direct and combined stresses. Design of cotter joint and knuckle joint.

Design of curved members- Rectangular, circular, trapezoidal and I-Cross sections.

Design of levers- Hand/foot lever, bell crank lever and lever for safety valve.

UNIT - 2 (12 Hours)

Flexible Power Drives: Classification and comparison of flexible drives.
Belt Drives- Flat belt and V belt drives, open and crossed belt drives, length of open and crossed belt drive, stresses in flat and V-belts, selection of flat and V-belts for industrial applications using Data Book/manufacturer's catalogue.
Design for Fatigue: Stress concentration, reasons, effects and methods to reduce stress concentration, fluctuating stresses, failure due to fatigue, S-N curve, endurance limit, endurance strength modifying factors, Design for finite and infinite life, Miner's equation, Soderberg, Goodman, Gerber criteria in designing for alternating stresses. Modified Goodman diagram. Design of components for fatigue under combined stresses.

UNIT - 3 (14 Hours)

Design of Joints: Threaded connections- Screw fastener classification, Terminology of ISO Metric threads, Bolted joint in tension, Eccentrically loaded threaded joints, Eccentric load on circular base, Threaded joints subjected to fatigue loading.
Welded Joints- Stresses in fillet and Butt welds. Strength of Parallel and Transverse fillet weld, Eccentrically loaded welded joints. Weld joints subjected to bending and twisting moments, Welded joints subjected to fatigue.
Design of Shafts: Design of shaft based on strength, torsional rigidity and lateral rigidity. Design of shaft based on A.S.M.E. code.
Design of Keys: Classification of keys, Design of Parallel, Taper Sunk keys, Woodruff key and Splines.
Design of Couplings: Classification and objectives of couplings, Design of Flanged Coupling and Flexible Bushed Pin Coupling.

UNIT - 4 (10 Hours)

Springs: Types, application and material for springs, Design equations for Helical Compression springs, Styles of ends, Design of Helical Compression and Tension Springs, Concentric Helical Springs, Helical Torsion Springs, surge in springs.
Multi-Leaf springs: Design equations for leaf springs, nipping of leaf springs, Design of Multi Leaf springs.

Recommended Readings:

1. V. B. Bhandari; Design of Machine Elements; Tata McGraw-Hill Education; 2010.
2. J. E. Shigley; Mechanical Engineering Design; Metric Edition; McGraw-Hill Publication; 1986.
3. A. S. Hall, A. R. Holowenko, H. G. Laughlin; Theory and Problems of Machine Design; Schaum's Outline Series; 1981.
4. C. S. Sharma, K. Purohit; Design of Machine Elements; PHI Learning Pvt. Ltd; 2009.
5. D. K. Aggarwal, P. C. Sharma; Machine Design; S. K. Kataria and Sons; 2013.
6. M. F. Spotts, T. E. Shoup; Design of Machine Elements, Prentice Hall International; 1998.
7. P. Childs; Mechanical Design Engineering Handbook; Butterworth-Heinemann; 1e; 2013.
8. R. L. Norton; Machine Design: An Integrated Approach, Pearson India; 2e; 2006.

Recommended Data Books for learning and examination:

1. PSG College Coimbatore - Kalaikathir Achchagam; Design Data Book; 2012.

2. K. Mahadevan, K. Balveera Reddy; Design Data Handbook for Mechanical Engineers, 4e, CBS Publishers; 2015.

Term Work shall consist of the following:

1. Design of Cotter joint and preparing assembly and production drawings.
2. Design of Knuckle Joint with assembly and production drawings.
3. Design of shaft transmitting power through belt drives, gears, mounted with flywheel, etc.
4. Design of coupling and preparing assembly and production drawings.

ME 5.3 ENERGY CONVERSION

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 5.3	Energy Conversion	3	1	2	3	100	25	--	25	--	**150**

Course Objectives:

1. Study of air standard and actual engine cycles.
2. Study of SI and CI engine components and processes involved
3. Study and analysis of engine performance characteristics and engine emissions
4. Study alternate fuels for IC Engine.

Course Outcomes:

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

1. Distinguish SI and CI engines
2. Identify and explain working of engines components/systems
3. Analyze engine performance characteristic
4. Perform exhaust gas analysis and comment on adverse implications on environment

UNIT-1 (12 hours)

Engine Construction and Operation: Heat engines; Internal and external combustion engines; Classification of I.C. Engines; Cycle of operations in four strokes and two-stroke IC engines and their comparative study.

Fuel Air Cycles and their Analysis : Introduction, Fuel Air Cycles & their significance, Variable Specific heat, Dissociation, Effect of no. of moles, Comparison of Air Standard & Fuel Air Cycles, Effect of operating Variables.

Actual Cycles and their Analysis: Introduction, Comparison of thermodynamic & Actual Cycles, various losses.

Fuels: Important qualities of the Engine fuels - SI and CI engines, Alternate fuels (SI & CI engines) - Liquid fuels, gaseous fuels.

UNIT-2 (12 hours)

Spark Ignition Engines: Theory of Carburetion, Types of carburetors, Multi-Point fuel injection system, GDI concept, Combustion in spark Ignition engines, stages of combustion, flame propagation, rate of pressure rise, abnormal combustion, Phenomenon of Detonation in SI engines, effect of engine variables on Detonation. Combustion chambers. Rating of fuels in SI engines, Additives.

Compression Ignition Engines: Fuel supply system, types of fuel pump, injector and distribution system, CRDI, Combustion in compression ignition engines, stages of combustion, factors affecting combustion, Phenomenon of knocking in CI engine. Effect of knocking, Types of combustion chambers, rating of fuels in CI engines. Dopes & Additives, Comparison of knocking in SI & CI engines.

UNIT-3 (12 hours)

Super Charging/Turbo-charging: Introduction, Objectives, Effect on power output and efficiency, Supercharging Systems, Turbo-charging, Characteristics of Supercharged Engines, Method of Super Charging, and Limits of Supercharging. Types of supercharging and turbo charging, relative merits, matching of turbocharger.

Engine Testing and Performance: Introduction to Indian Standards for testing of I.C. Engine, Mean effective pressure, indicated power, brake power, friction power, Methods to determine power and efficiencies Variables affecting performance of engine, characteristic curves, heat balance sheet, Methods of improving engine performance.

UNIT-4 (12 hours)

Cooling and Lubrication System: Need for cooling system. Types of cooling system, Liquid cooled system, Thermo-syphon system and Pressure cooling system. Lubrication system, Mist lubrication system, Wet sump and dry sump lubrication. Properties of lubricants. Properties of coolants.

Emissions of I. C. Engines: Air pollution due to IC engine, Engine emissions, Hydrocarbon emissions and PPM & Carbon monoxide emissions (CO), oxides of Nitrogen (NOx) Euro norms, Bharat stage norms, Introduction to EDC and IDC, Introduction to carbon credit, Emission control methods for SI and CI engines, Electronic Control Unit, Catalytic converter, Exhaust Gas Recirculation, Diesel Particulate Filter.

Alternative Potential Engines: VCR engine, Dual fuel engines, Multifuel engines, Heterogeneous Charge Compression Ignition, Modern Trends in I. C. Engines.

Recommended Readings:

1. W. W. Pulkrabek; Internal Combustion Engines; Pearson Education; 2004.
2. S. Agrawal; Internal Combustion Engines; New Age International, 2e; 2006.
3. M. L. Mathur, R. P. Sharma; Internal Combustion Engine; Dhanpat Rai Publication; 2010.
4. R. K. Mohanty; Internal Combustion Engines; Standard Book House; 2007.
5. P. W. Gills, J.H. Smith; Internal Combustion Engine, Oxford and IBH Pub. Ltd.; 1959.
6. J. B. Heywood; Internal Combustion Engines Fundamentals; McGraw Hill Education, 1st edition; 2017.
7. H. N. Gupta; Internal Combustion Engines; 2nded, Prentice Hall of India; 2013.
8. V. Ganesan; Internal Combustion Engine; Tata McGraw Hill, 4th edition; 2017.
9. R. Stone; Internal Combustion Engines; Palgrave Publication; 2012.

List of Experiments:

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

1. Study of I.C. Engines-2 Stroke and 4 Stroke Engines, Carburetor, Ignition system and Fuel injection system.
2. Morse Test on multi-cylinder petrol engine.
3. Speed Test on petrol engine.
4. Speed Test on diesel engine
5. Load Test on petrol engine.
6. Load Test on diesel engine.
7. Heat Balance test on petrol engine.
8. Heat Balance test on diesel engine.

9. Exhaust Gas analysis of S.I./ C.I. engines.
10. Smoke analysis of C.I. engines.
11. Effect of Supercharging on Performance Characteristics of an engine.
12. Willan's Line method to calculate frictional power.
13. Motoring test on IC Engine.

ME 5.4 MANUFACTURING TECHNOLOGY II

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 5.4	Manufacturing Technology II	3	--	2	3	100	25	--	25	--	**150**

Course Objectives:

1. To understand the fundamentals of metal cutting.
2. To study the cutting tool geometry, tool material requirement and commonly used tool materials.
3. To understand different operations on the basic workshop machines.
4. To understand use of dynamometers and economics involved in a machining workshop.
5. To study gear manufacturing and unconventional machining processes.

Course Outcomes:

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

1. Understand the basic theory of metal cutting.
2. Understand the significance of Merchant theory.
3. Understand tool wear mechanisms and able to determine tool life.
4. Analyze single point cutting tool geometry.
5. Understand cutting forces in machining operation.
6. Analyze the economics involved in machining operation.
7. Understand gear manufacturing processes and other unconventional machining processes.

UNIT - 1 (12 Hours)

Theory of Metal Cutting: Wedge shaped tool and its features. Orthogonal and oblique cutting, tool geometry (ASA & ISO). Chip formation and types of chips. built-up-edge. chip thickness ratio. Velocity diagram, shear strain in metal cutting. Concept of feed, speed, depth of cut and cutting forces in turning. milling. drilling and grinding. Effect of various parameters on cutting forces. Effect of different parameters on surface finish. Expression for the height of feed ridges. Ernst Merchants Theory and its modification- Expression for shear plane angle.

UNIT - 2 (12 Hours)

Cutting Tool Materials: Basic requirements, selection, study of high carbon steel, high speed steel, cemented carbides, coated tools, ceramics and diamonds.

Tool Life and Tool Wear: Definitions. Symptoms of end of tool life. Tool life equation. Tool wear mechanisms. wear types. Tool life criteria. Effect of built-up-edge and tool angles on tool life.

Single Point Cutting Tool Geometry: Definitions and significance of various angles in plan view and in different sections. Relationship between these angles.

UNIT - 3 (12 Hours)

Machining Operations: Basic operations performed on lathe, milling. grinding, broaching, shaping and planning.
Economics of Machining: Introduction, machining time and associated cost criteria for feed choice. Expressions for optimum cutting velocity under different criteria. Restrictions for feed choice.
Machinability: Definition. Different criteria for assessing machinability. Machinability ratings.
Cutting Fluids: Objectives. Requirements, classification, selection of cutting fluids.
Dynamometers: Introduction. Requirements. Dynamometers for turning, milling, drilling and grinding operations.

UNIT - 4 **(12 Hours)**

Unconventional Machining: Introduction and necessity. Ultrasonic Machining. Electric discharge machining. Electrochemical machining. Abrasive jet machining. Laser beam machining. Electron beam machining.
Gear Manufacturing: Gear cutting processes: Gear hobbing. Gear shaping. Gear lapping, Gear grinding and Gear broaching.

Recommended Readings:

1. P. N. Rao; Manufacturing Technology; Vol II; Tata McGraw Hill Education; 2017.
2. G. K. Lal, S. K. Choudhary; Fundamental of Manufacturing Processes; Narosa Publishing House; 2014.
3. A. Ghosh, A. K. Malik ; Manufacturing Science ; East-West Press Pvt. Ltd.; 2010.
4. B. L. Juneja, G. Sekhon., Fundamentals of metal machining and machine tools; Wiley Eastern Ltd; 2015.
5. E. M. Trent; Metal Cutting; Butterworths; 2000.
6. M. C. Shaw; Metal Cutting Principles; CBS Publishers & Distributors; 2002.
7. HMT; Production Technology; Tata McGraw-Hill Education, New Delhi; 2001.
8. E. P. DeGarmo, J .T. Black, R. A. Kohser; Materials and Processes in Manufacturing; Wiley; 2003.
9. P. C. Pandey, C.K. Singh; Production Engineering Sciences ;Standard Publishers Distributors;2006.
10. B. J. Ranganath; Metal Cutting & Tool Design; Vikas Publishing House Pvt. Ltd.; 1999.
11. G. Boothroyd; Fundamentals of Metal Machining & Machine Tools; Tata McGraw Hill; 1975.

List of Experiments:

Following jobs have to be completed during the practical slot:
A. Three machining jobs involving following operations:

1. Plain Turning
2. Facing
3. Step turning,
4. Taper turning,
5. External and internal thread cutting,
6. Knurling
7. Eccentric

8. Forming
9. Drilling

and

B. One job on gear cutting operation.

ME 5.5 DYNAMICS OF MACHINERY

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 5.5	Dynamics of Machinery	3	--	2	3	100	25	--	--	--	**125**

Course Objectives:

1. This course shall help the student to understand the static and dynamic analysis of rigid bodies.
2. This course shall help the student to apply the concept of static and dynamic analysis to mechanisms.
3. To understand and apply the principle of static and dynamic balancing.
4. To understand the working principles and applications of governors, dynamometers and gyroscopes.

Course Outcomes:

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

1. Apply the principles of rigid body dynamics in real life situations.
2. Understand the use of force analysis in analyzing transmission systems.
3. Apply the concepts of dynamics in analyzing balancing of reciprocating and rotating masses.
4. Analyze the effects of dynamic forces in gyroscopes.

UNIT - 1 (12 Hours)

Rigid Body Dynamics: Acceleration of a rigid body, Mass distribution, Angular momentum of a rigid body, Newton's and Euler's Equations for motion. Use of D-Alembert's principle.

Principle of work and energy, Conservation of energy, principle of impulse and momentum, Conservation of angular momentum.

Gyroscopes: Vectorial representation of angular motion. Gyroscopic couple. Effect of gyroscopic couple on Ship, Plane disc, Aeroplane, Stability of two wheelers and four wheelers.

UNIT - 2 (12 Hours)

Static and Dynamic Force Analysis: Four-bar, Reciprocating Engine Mechanism, Spur Gears, Cam and follower Mechanism. Analytical and graphical methods.

Inertia effect of Reciprocating mass and Connecting rod.

Flywheels: Torque analysis, Coefficient of fluctuation of speed and coefficient of fluctuation of energy, Turning moment diagrams, Determination of size of flywheels, Flywheels in Punching Press.

UNIT - 3 (12 Hours)

Balancing of Rotating Masses: Static and dynamic balancing, two plane balancing, field balancing of rotors, balancing machines

Balancing of Reciprocating Masses: Primary and secondary unbalance, balancing of Multi-cylinder in-line Engines, Radial engines, V-engines, W-engines, Opposed piston Engines.

Partial Balancing of Locomotives and its effects: Theoretical aspects on variation in Tractive Force, Swaying Couple and Hammer Blow

UNIT - 4 **(12 Hours)**

Belt, Rope and Chain Drives: Flat Belts, V-belts, angular velocity, effect of slip, Law of belting, Cone pulleys, crowning, belt tension ratio, effect of belt and centrifugal tension on power transmitted, creep in belt drives, Power transmission using Wire ropes, Ratio of driving tensions for rope drive, Types of chains, Power transmission using Chains.

Dynamometers: Absorption type - Prony brake and Rope brake, Transmission type - Epicyclical train, belt transmission, Torsion dynamometers.

Governors: Types of governors, Force analysis of Porter, Proell, Hartnell and Inertia governors. Controlling force, stability, sensitiveness, Isochronism, effort and power.

Recommended Readings:

1. A. Ambekar; Mechanism and Machine Theory; Prentice Hall of India; 2007.
2. J. S. Rao, R. V. Dukkipati: Mechanism and Machine Theory; New age International; 1989.
3. S. S. Rattan; Theory of Machines and Mechanisms, Tata McGraw Hill; 2017.
4. J. E. Shigley, J. J. Uicker; Theory of Machines and Mechanisms; McGraw Hill; 2010
5. A. Ghosh, A. K. Malik; Theory of Mechanisms and Machines; East west Publishers; 3e. 2006.
6. I. Shames, G. K. M. Rao: Engineering Mechanics: Statics and Dynamics; Pearson Education; 2009.
7. F. P. Beer, E. R. Eisenberg, E. R. Johnston, W. E. Clausen: Vector Mechanics for Engineers; Tata McGraw Hill, 10e; 2013.
8. P. L. Ballaney; Theory of Machines and Mechanisms; Khanna Publication; 2001.

List of Experiments:

(Following experiments should be conducted from the list of experiments)

1. Static and dynamic balancing of rotating masses.
2. Characteristics of Dead Weight controlled governor.
3. Characteristics of Spring controlled governor.
4. Verification of Gyroscopic Rule.
5. Three Sheets on force Analysis of Mechanisms (Static and Dynamic).
6. Three Sheets on Balancing.

ME 5.6 ENGINEERING MEASUREMENTS AND METROLOGY

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 5.6	Engineering Measurements and Metrology	3	--	2	3	100	25	--	--	--	**125**

Course Objectives:

1. To inculcate in students the habit of giving importance to metrology and measurement.
2. To read and understand the geometric representations on the drawing.
3. To apply the concepts in measurement of screw threads, gears, etc.
4. To apply measurement concepts in real-world situations.

Course Outcomes:

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

1. Understand use of Tolerance and its notations as appearing on drawing sheets.
2. Measure various dimensions of screw threads and gears.
3. Apply measurement methods for measuring Force, Torque, Pressure and Temperature.
4. Understand working of Nanometrology and its applications.

UNIT-1 (12 hours)

Basic Principles of Engineering Measurement: Introduction to Metrology, Need for Inspection, Accuracy and Precision, Accuracy and Cost, Objectives of Metrology and Measurements, Process Measurement Concepts, Calibration of Measuring Instruments, Errors in Measurements, Systematic and Random Errors, Methods of Measurement.

Standards of Measurement: Introduction, Standards and their Roles, Evolution, Material Standard, Wavelength Standard, Line and End Measurements, Transfer from Line Standard to End Standard, Displacement Method, Calibration of End Bars.

Linear Measurement: Depth gauge, Callipers, Vernier Instruments, Micrometer Instruments, Slip Gauges: Sizes and Grades, Wringing, Manufacture and Calibration.

Angular Measurement: Protractors, Sine Bars, Angle gauges and its calibration, Autocollimator, Angle Dekkor, Clinometer.

UNIT-2 (12 hours)

Comparators: Classification, Types, Advantages, Limitations and Applications: Mechanical, Mechanical-Optical, Optical, Electrical, Electronic, Pneumatic.

Optical Measurement and Interferometry: Introduction, Tool Makers' Microscope, Profile Projector, Optical Interference, Interferometry, NPL flatness Interferometer, Laser Interferometer.

Limits, Fits, and Tolerances: Introduction, Principle of Interchangeability, Tolerances, Fits, System of Limits and Fits, Indian Standard limit fit system, Limit gauging, Taylor's Principle of Gauge Design, Gauge Tolerance, Wear Allowance, Plug and Snap gauges.

Geometric Dimensioning and Tolerancing: Introduction, Standard symbols and terminology, standard drawing, practice, and their interpretation.

UNIT-3 (12 hours)

Metrology of Gears: Errors in Spur Gears, Measurement of Gear elements: Runout, Pitch, Lead, Tooth Thickness, Gear Tooth Calliper, Tooth span micrometers, Parkinson Gear tester

Metrology of Screw Threads: Measurement of Screw Thread elements: Major diameter, Minor diameter, Effective diameter using One-wire method, two-wire method and Three-wire method, Pitch. Thread gauges.

Metrology of Surface Finish: Concepts, Terminology, Analysis of Surface traces, Tomlinson Surface Meter, Taylor-Hobson Talysurf.

Machine Tool Metrology: Straightness, Flatness, Parallelism, Squareness, Roundness, Cylindricity and Runout

Coordinate Measuring Machines: Introduction, Structure, Modes of Operation, Probe, Operation.

Machine Vision: Stages and Applications.

UNIT-4 (12 hours)

Force Measurement: Load cells, Cantilever beams, proving rings.

Torque Measurement: Torsion-bar Dynamometer, Servo-controlled Dynamometer, Prony brake Dynamometer.

Temperature Measurement: Thermocouples, Thermopiles, Thermisters, Pyrometers: Total Radiation pyrometer, Optical pyrometer.

Pressure measurement: Pressure measurement Scales, Industrial U Tube Manometer, Bourdon tube pressure Gauges, McLeod Gauges.

Nanometrology: Nanodimensions, Importance of Nanometrology, Transmission Electron Microscope and Scanning Electron Microscope.

Recommended Readings:

1. N. V. Raghavendra, L. Krishnamurthy; Engineering Metrology and Measurements; Oxford University Press; 2015.
2. A. K. Bewoor, V. A. Kulkarni; Metrology and Measurement; McGraw Hill; 2015.
3. E. Doebelin, D. Manik; Measurement Systems; McGraw Hill; 2011.
4. C. Dotson; Fundamentals of Dimensional Metrology; Cengage Learning; 2012.
5. R. K. Jain; Engineering Metrology; Khanna Publishers; 21e; 2015.

List of Experiments:

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

1. Measurement by Using Vernier Calliper (Dial, Digital and Plain).
2. Measurement of dimensions using Vernier Height Gauge.

3. Measurement of dimensions using Micrometer Screw Guage (Digital and Plain).
4. Measurement of angle using Sine bar/Sine center.
5. Measurement of Angle using Bevel Protractor.
6. Measurement of Angle using Height Gauge.
7. Use of Dial Gauge as Mechanical Comparator.
8. Measurement of straightness and roundness using Dial Gauge.
9. Measurement of Surface Roughness using Surface Roughness Tester.
10. Measurement of various elements of screw thread using Tool Makers Microscope.
11. Measurement of Screw thread parameters using Floating Carriage Micrometer.
12. Measurement of Gear tooth thickness using Gear tooth Vernier caliper and Span Micrometer.
13. Linear and angular measurement using Profile Projector.
14. Measurement using CMM.
15. Process Capability Analysis on measured data.
16. Calibration of Vernier Calliper (Dial, Digital, Plain) by using Slip Gauges.
17. Calibration of Micrometer (Digital, Plain) by using Slip Gauges.
18. Calibration of LVDT.
19. Calibration of Piezo electric transducers.
20. Calibration of Strain Gauge.
21. Calibration of Load cell.
22. Calibration of Pressure cell.

ME 6.1 QUALITY AND RELIABILITY

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
					Th Duration (Hrs)	Marks					
		L	T	P		Th	S	TW	P	O	Total
ME 6.1	Quality and Reliability	4	1	--	3	100	25	--	--	25	**150**

Course Objectives:

1. To make the students aware about importance of quality and its effect on bottom line of the organization.
2. To introduce statistical process control and acceptance sampling as methods of online and off line quality improvement tools.
3. To study reliability and its importance with respect to the life of the product.
4. To study various mathematical expression of reliability as well as probabilistic design methodology.

Course Outcomes:

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

1. Understand the importance of Statistical Process Control and its role in variation reduction.
2. Understand use of Acceptance Sampling method in quality improvement.
3. Perform mathematical analysis in Reliability studies.
4. Design mechanical components in probabilistic environment.

UNIT-1 (16 hours)

Quality: Introduction and its role in industry, Quality Costs, Quality of conformance, Quality of design, Quality of performance. Quality Philosophies, Role of Quality Assurance department.

Introduction to Six Sigma, Zero Defect and Zero Effect, ISO 9001 quality standards, TQM.

Statistical Quality control: Introduction and methods, Quality tools: Flow Chart, Histogram, Pareto chart, Cause and Effect diagram, Scatter diagram. Statistical Process Control- Introduction, Chance and Assignable causes of Quality Variation, Statistical Basis of the Control Chart.

Variable Control Charts: Introduction, Statistical basis of the Charts, Development and Use of Sample Mean and Range Charts, Development and Use of Sample Mean and Standard Deviation Charts, Charts based on Standard Values, Interpretation, Analysis of pattern, Type I and II errors, Average Run Length (ARL), Average Time to Signal (ATS), Operating-Characteristic (O.C.)Curve, Process Capability studies.

UNIT-2 (16 hours)

Control Charts for Attributes: Introduction, Control charts for non-conforming items (p, np charts)- Statistical Basis, Development and Operation, Fixed sample size and Variable sample size, Type I and II errors, O.C. curve and ARL.

Control charts for non-conformities (C, U charts)- Statistical Basis, Development and Operation, Fixed sample size and Variable sample size, Type I and II errors, O. C. curve and ARL.

Acceptance Sampling by Attributes: Introduction, Advantages and Disadvantages of sampling, Single, double and Multiple sampling plans - Calculation of Probability of acceptance, O. C. Curve; Military Standard System- Terminology, referring tables, Designing single, double and multiple sampling plans; Dodge-Romig system- Terminology, referring tables, Designing single and double sampling plans; Use of Cameron table- Designing Single Sampling Plan; Sequential Sampling Plan- design and application.

UNIT-3 (16 hours)

Reliability Engineering: Need for Reliability, definition of reliability and its various measures, reliability analysis- Exponential, Normal, Lognormal and Weibull distribution.

Reliability of Systems - Series, Parallel and Combined Series-Parallel systems, Complex systems, Three-State Devices, Standby Redundant system with Perfect switching, Common-Mode failures, Fault Tree Analysis (FTA).

Reliability Allocation - Equal Apportionment technique, ARINC Apportionment technique, AGREE Allocation method.

Reliability Optimization by Dynamic Programming.

UNIT-4 (16 hours)

Reliability-based Design: Probabilistic Design Methodology. Combination of random variables in design- Transformation of Random variables, Expectation and Variance of a function of Random Variables, Approximation for E-Operator and V-operator of function of random variables, Statistical Tolerancing.

Interference Theory: Computation of reliability with stress and strength following Exponential, Normal, Lognormal.

Reliability-based Design of Mechanical Components: Shaft (Tension and Torsion), I-beam, Connecting Rod, Pressure Vessel, Helical Spring.

Recommended Readings:

1. D. C. Montgomery; Statistical Quality Control: A Modern Introduction; Sixth Edition, Wiley India; 2009.
2. C. E. Ebeling; An Introduction to Reliability and Maintainability Engineering; Tata McGraw Hill; 2000.
3. K. C. Kapur, L. R. Lamberson; Reliability in Engineering Design; Wiley India; 1997.
4. S. S. Rao; Reliability Engineering, Pearson Education; 2016.
5. A. Mitra; Fundamentals of Quality Control and Improvement; Third Edition; Wiley India; 2008.
6. E. L. Grant, R. S. Leavenworth; Statistical Quality Control; Seventh Edition; McGraw Hill India; 2000.
7. R. K. Jain, H. M. Trivedi; Quality Management for Zero Defect and Zero Effect: A Compendium of Case Studies and Best Practices; American Society for Quality India; 2016.

Assignments:

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

ME 6.2 MACHINE DESIGN – II

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 6.2	Machine Design - II	3	--	2	3	100	25	25	--	--	**150**

Course Objectives:

1. To inculcate the belief that the real life problems in design are not closed bound.
2. To demonstrate the methodology of designing near real life situations through problem solving
3. To enable the student to acquire knowledge about selection of appropriate machine components for given applications.
4. To enable the student to apply engineering tools and techniques to product design.

Course Outcomes:

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

1. Design a clutch and braking system.
2. Select, analyze and design power transmission systems.
3. Select appropriate bearings from manufacturer's catalogue.
4. Design a suitable journal/sliding contact bearing to meet the specifications.

UNIT - 1 (14 Hours)

Clutches: Torque transmitted by single plate, multi-plate, and cone clutch. Design of clutch plate, pressure plate, springs & lever. Design of Centrifugal clutch.

Brakes: Similarity and difference between brake and clutch, energy equations, Classification of brakes, block or shoe brake, band brake, pivoted shoe brake, internal expanding shoe brake, and disc brakes. Thermal considerations in Brakes.

Flywheel: Review of- Torque analysis in Flywheel, Coefficient of fluctuation of speed and coefficient of fluctuation of energy, Stress analysis in solid disc flywheel and rimmed flywheel.

Design of flywheel for I.C. Engines and Punch Press applications.

UNIT - 2 (10 Hours)

Bearings:

Sliding Contact Bearings: Types of lubrication, viscosity, Petroff's law, Stable lubrication, Thick-film lubrication, Bearing Modulus, Introduction to hydrodynamic theory, Reynold's equation and dimensionless numbers, Types of Journal bearings, Full and partial bearings, Heat dissipation of bearings, bearing materials, journal bearing design.

Rolling Contact Bearings: Classification, selection criteria, static load carrying capacity, Stribeck's equation, Dynamic Load carrying capacity, Load - Life relationship, selection of ball and roller bearings from manufacturer's catalogue, Bearing selection for criteria other than L_{10} life, RC bearings subjected to cyclic loads and speeds, Mounting of bearings.

UNIT - 3 (14 Hours)

Gears: Classification of gears, selection of Gears, Law of Gearing.

Spur Gears: Terminology, Interference, Backlash, Force Analysis, Gear Tooth failures, Beam strength, and Wear Strength of Gear Tooth based on Buckingham's approach and Spott's approach, Estimation of module based on beam and wear strength, heat treatment of gears, Gear lubrication.

Helical Gears: Terminology, Force analysis, Formative or virtual teeth, Beam strength and wear strength of helical gears, Estimation of module based on beam and wear strength, Herringbone gears.

Worm Gears: Terminology, proportions of worm Gears, Force Analysis, material selection, Strength and wear rating of worm gears, Thermal considerations in design of worm gears.

UNIT - 4 (10 Hours)

I.C. Engine Components: Design of - Connecting Rod, Piston and Cylinder of IC Engines.

Power Screws: Design of Screw and Nut for common engineering applications with Square, Acme and Buttress threads.

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

Recommended Readings:

1. V. B. Bhandari; Design of Machine Elements; Tata McGraw-Hill Education; 2010.
2. J. E. Shigley; Mechanical Engineering Design; Metric Edition; McGraw-Hill Publication; 1986.
3. A. S. Hall, A.R. Holowenko, H.G Laughlin; Theory and Problems of Machine Design; Schaum's Outline Series; 1981.
4. C. S. Sharma, K. Purohit; Design of Machine Elements; PHI Learning Pvt. Ltd; 2009.
5. D. K. Aggarwal, P. C. Sharma; Machine Design; S.K Kataria and Sons; 2013.
6. M. F. Spotts, T. E. Shoup; Design of Machine Elements, Prentice Hall International; 1998.

Recommended Data Books for learning and examination:

1. PSG College Coimbatore - Kalaikathir Achchagam; Design Data Book; 2012.
2. K. Mahadevan, K. Balveera Reddy; Design Data Handbook for Mechanical Engineers, 4e, CBS Publishers; 2015.

Term Work shall consist of the following:

1. Design of a single plate or multi plate clutch and preparing assembly and production drawings.

2. Design of any one of the following - Screw Jack, Power Press, C Clamp, Lead Screw of a Lathe, etc. and preparing assembly and production drawings.

3. Selection of Rolling Contact bearing for a given application.

4. Design of a Spur or Helical Gear and preparing a drawing of the designed pair of gears in mesh showing at least two pairs of teeth in mesh.

ME 6.3 GAS DYNAMICS AND TURBOMACHINERIES

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
					Th Duration (Hrs)	Marks					
		L	T	P		Th	S	TW	P	O	Total
ME 6.3	Gas Dynamics and Turbomachineries	3	1	2	3	100	25	--	25	--	**150**

Course Objectives:

1. Introduce the fundamental concepts of compressible flow.
2. Understand conceptually Flow with Shock wave.
3. Understand the fundamental concepts of turbo machinery.
4. Understand the fundamental concepts of Hydraulic Turbine, Centrifugal Pump.

Course Outcomes:

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

1. Analyze compressible flow analysis through ducts.
2. Analyze power generating and absorbing turbomachines.
3. Understand the basics of flow with normal Shock waves and heat transfer.
4. Analyze performance of Centrifugal pump.

UNIT-1 (12 hours)

Introduction to Compressible Flow: Thermodynamics of compressible flow, perfect gases, Reynolds transport theorem, integral form of conservation equations: conservation of mass, conservation of momentum and conservation of energy. Sonic velocity and Mach number, wave propagation - mach cone & Mach angle, Regimes of flow, Prandtl velocity ellipse, concept of stagnation and reference/characteristic states, Alternate form of energy equation, Effect of Mach number on compressibility.

1D Steady Isentropic Flow in Variable Area Passages: Governing equations, effect of area change on flow properties, Flow through nozzles: Area - Mach number relations, Impulse function, effects of different pressure ratios across a supersonic nozzle, under expansion & over expansion, mass flow rate in nozzles, Flow through diffusers.

UNIT-2 (12 hours)

Flow with Normal Shock Wave:

Introduction and development of normal shocks, Governing equations, Prandtl relation, Change in Mach number across a shock wave, Change in properties across a shock wave - Static pressure, temperature and density, stagnation pressure and stagnation temperature.

Flows with Heat transfer and Friction: Hugoniot equation and Hugoniot curve, One dimensional flow with heat addition, the Rayleigh Curve, One dimensional flow with friction, the Fano curve.

UNIT-3 (12 hours)

Introduction to Turbomachines: Definition and classification, Application of First law & Second law to turbomachines, Efficiencies of turbomachines, Unit and specific values

Energy Exchange in Turbomachines: Velocity triangles and Euler turbine equation and alternate form, Impulse & reaction, Turbine utilization factor. Enthalpy-Entropy diagrams for power generating and power absorbing turbomachines.

UNIT-4 **(12 hours)**

Hydraulic Turbines: Introduction and classification of turbines, selection based on specific speed, Pelton turbine: construction, work done & efficiencies, design parameters, Francis turbine: construction, work done and efficiencies, Kaplan turbine: Construction, work done & efficiencies.

Centrifugal Pumps: Construction & classification, Types of heads and efficiencies, Velocity triangles and analysis - effect of blade outlet angle on energy transfer, Characteristic curves, Minimum speed, NPSH and cavitation, Series & parallel arrangement, System resistance curve & operating point.

Recommended Readings:

1. J. Anderson; Modern Compressible Flow; Tata McGraw Hill,3rd edition; 2012.
2. P. Balachandran; Fundamentals of Compressible Flow; Prentice Hall India Learning Private Limited; 2006.
3. S. M. Yahya; Fundamentals of Compressible Flow; New Age International Publishers; 2002.
4. B. U. Pai; Turbomachines; Wiley India; 2014.
5. R. K. Rajput; Fluid Mechanics & Hydraulic Machines; S. Chand & Co.; 2016.
6. B. K. Venkanna; Fundamentals of Turbomachineries; Prentice Hill of India; 2009.
7. P. R. Somasundaram; Gas Dynamics and Jet Propulsions; New Age International Publishers; 1996.
8. V. Babu; Fundamentals of Gas Dynamics; ANE Books India; 2011.
9. H. Cohen; G. F. C. Rogers, H. I. H. Saravanamutto; Gas Turbine Theory; Longman Group Ltd.; 1980.
10. V. Ganesan; Gas Turbines; Tata McGraw Hill Publishers; 2e; 2003.

List of Experiments:

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

1. Characterization of a Nozzle.
2. Performance Test on Pelton Wheel.
3. Performance Test on Francis Turbine.
4. Performance Test on Kaplan Turbine..
5. Performance Test on Single Stage Centrifugal Pump
6. Performance Test on Multi Stage Centrifugal Pump.
7. Performance Test on Reciprocating Pump.
8. Performance Test on Single stage Reciprocating Air Compressor test rig.
9. Performance Test on Two stage Reciprocating Air Compressor test rig.
10. Performance Test on Blower test rig.
11. Performance test on Gear pump test rig.

12. Performance test on Vane pump test rig

ME 6.4 MECHANICAL VIBRATIONS

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
					Th Duration (Hrs)	Marks					
		L	T	P		Th	S	TW	P	O	Total
ME 6.4	Mechanical Vibrations	3	--	2	3	100	25	--	25	--	**150**

Course Objectives:

1. Understand and appreciate the phenomenon of vibrations.
2. Obtain linear vibratory models of dynamic systems and obtain natural frequencies.
3. Formulate and solve the differential equation of motion of vibratory systems.
4. Analyze the free and forced vibration effects of systems using classical and numerical methods.

Course Outcomes:

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

1. Analyze vibrations in mechanical systems and structures.
2. Model linear vibratory system and synthesize its response.
3. Predict vibratory responses to harmonic, periodic and non-periodic excitation.
4. Relate the experimental determination of vibration parameters for condition monitoring and modal analysis.

UNIT - 1 (12 Hours)

Free & Forced Vibration of Single Degree Freedom System: Periodic motion and related concepts, Model of a single degree freedom (SDOF) system, governing equation for damped and un-damped free vibration, Determination of natural frequency by Newton's method & Energy method. Logarithmic Decrement.

Response to harmonic excitation of SDOF systems with fixed support, system response to support excitation, Rotating and reciprocating unbalance.

UNIT - 2 (12 Hours)

Vibration Control: Vibration Isolation and transmissibility, Isolator design (damped and undamped), Design of dynamic vibration absorbers (damped and undamped).

Transient Vibration: Response to transient excitation for step, ramp, impulse, exponential, sinusoidal and combination inputs using Duhamel integral, Laplace transform and phase plane technique. Shock response spectrum (S.R.M), Drop Test.

UNIT - 3 (12 Hours)

Systems with Multi-Degrees of Freedom (Exact Analysis): Properties of vibrating systems, free vibration, Eigen value problem, use of stiffness and flexibility influence coefficients.

Critical Speed of shafts.

Numerical Methods: Rayleigh's method, Dunkerley's method, Method of Matrix Iteration, Stodola and Holzer's method**.**

UNIT - 4 (12 Hours)

Experimental Methods in Vibration Analysis: Vibration exciters and measuring Instruments, Signal Analysis Techniques (Time domain, Frequency domain & Cepstrum analysis), Amplitude and Power Spectra, Coherence, Auto and Cross- correlations. Amplitude and Frequency Modulation, Fast Fourier Transform (FFT) Analyzer.

Frequency Response: Sinusoidal Input, Phasors, Frequency Response, Bode Plots, Stability.

Recommended Readings:

1. J. S. Rao, K. Gupta; Theory & Practice Of Mechanical Vibrations; New Age International; 2e; 1999.
2. G. K Grover; Mechanical Vibrations; Nem Chand & Bros; 8e; 2009.
3. A. Ambekar; Mechanical Vibrations and Noise Engineering; Prentice Hall of India Pvt. Ltd.; 2006.
4. S. S. Rao; Mechanical Vibrations; Pearson Inc; 4e; 2004.
5. W.T. Thomson; Mechanical Vibrations; Prentice Hill India; 5e; 2007.
6. L. Meirovitch; Fundamentals of Vibrations; McGraw Hill International; 2001.
7. V. P. Singh; Mechanical Vibrations; Dhanpat Rai S.K. Kataria & Sons; 3e; 2006.

List of Experiments:

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

1. Determination of natural frequency of single DOF systems - spring mass system and/or simple pendulum and/or single rotor system.
2. Determination of mass moment of inertia of a given rigid body by suspending it as a compound pendulum, bifilar suspension and trifilar suspension.
3. Determination of natural frequencies of vibration of two DOF system.
4. Determine the damping ratio in a damped single degree of freedom system.
5. Performance characteristics of forced vibration.
6. Condition monitoring using vibration measuring and analyzing instrument.
7. Verification of Dunkerley's rule to determine the natural frequency of multiple degrees of freedom system.
8. To draw response of single degree of freedom system to varying frequency of excitation on non dimensional plane.
9. Experimental Modal Analysis using Data Acquisition System.
10. Determination of natural frequencies of a Multi DOF systems using Holzer's method.
11. Simulation of Multi DOF systems using MATLAB.

ME 6.5 MECHATRONICS

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 6.5	Mechatronics	3	--	2	3	100	25	--	--	--	**125**

Course Objectives:

1. To describe key elements of Mechatronics system.
2. To have a basic understanding of Control systems.
3. To understand principles of sensors, signal conditioning & data acquisition.
4. To understand the concept of system modeling and analysis.
5. To understand basics of hydraulic & pneumatic actuation systems.
6. To understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application.
7. To get a brief overview of MEMS.

Course Outcomes:

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

1. Identify key elements of mechatronics system.
2. Compare various Control Modes.
3. Develop basic system models.
4. Outline various signal conditioning devices for mechatronic systems.
5. Construct simple Fluid Power Circuits.
6. Develop PLC ladder programs.
7. Describe various MEMS components.

UNIT - 1 (12 Hours)

Introduction to Mechatronics: Definition, open loop & closed loop control systems, Basic elements of closed loop control system, Application of microprocessor based control system to automatic washing machine.

Concepts of Control Engineering: Review of Laplace transform, Transfer function, First order system with time response specifications subjected to unit step, ramp & impulse inputs, numerical problems on time response of first order systems, concept of second order system with time response specification, basics of proportional, integral, derivative, PI, PD, PID controllers.

UNIT - 2 (12 Hours)

Sensors: Performance terminology of sensors, RTD sensor, Encoders, Capacitive & Inductive proximity sensor, Photoelectric sensor, Selection of Sensors.

System Models: Mathematical models, Electrical system building blocks, Mechanical system building blocks, Electrical & Mechanical analogies, Fluid system building blocks, Thermal system building blocks.

Signal Conditioning: Operational amplifier with pin diagram, only inverting & non inverting amplifier, Filtering-low pass, high pass, band pass, band stop, principle of Analog to digital conversion, principle of Digital to analog conversion, protection, principle of operation of multiplexers.

Data acquisition: Basics of PC based data acquisition, Concept of Virtual Instrument.

UNIT - 3 (12 Hours)

Pneumatic & Hydraulic Actuation Systems: Introduction, basic control valves (direction, pressure, flow), actuators (linear, rotary), basic hydraulic and pneumatic circuits, Process control valve.

Electrical Drives: Relay, Solenoid, PWM, Brief overview of variable frequency drives, Brief overview of stepper motor driver and controller, communication interface standard RS232, basics of CAN & MODBUS.

UNIT - 4 (12 Hours)

Programmable Logic Controllers: Introduction to PLC, block diagram of PLC, PLC architecture, I/O units & I/O processing, Introduction to ladder programming using logic gates, latching, timers, counters, selection of PLC.

Overview of MEMS: Basic concept of MEMS as micro sensor & micro actuator, basic concept of micro gear, micro motor, micro turbine, micro optical components, Intelligent Microsystems.

Recommended Readings:

1. W. Bolton; Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering; Pearson; 3e; 2005.
2. D. Necsulescu; Mechatronics; Pearson; 2002.
3. D. A. Bradley, D. Dawson, N.C. Burd, A. J. loader; Mehatronics: Electronics in Products & Processes; Nelson Thornes Ltd. (India); 2004.
4. C. W. de Silva; Mechatronics: A Foundation Course; CRC Press (Indian edition); 2013.
5. A. Smaili, F. Mrad; Mechatronics: Integrated technologies for Intelligent Machines; Oxford University press; 2009.
6. K. P. Ramachandran, G. K. Vijayaraghavan, M. S. Balasundaram; Mechatronics: Integrated Mechanical Electronic systems; Wiley India; 2015.
7. D. G. Alciatore, M.B. Histand; Introduction to Mechatronics and Measurement Systems; Tata McGraw Hill; 2e; 2003.
8. D. Shetty, R. A. Kolk; Mechatronics System Design; Cengage; 2e; 2012.
9. T. C. Chang, R. Wysk, H. P.Wang; Computer Aided Manufacturing, Pearson; 3e; 2010.
10. J. Prasad, M. N. Jayaswal, V. Priye; Instrumentation & Process Control, I. K. International Publishing House Pvt Ltd; 2012.
11. T. Hsu; MEMS & Microsystem Design & Manufacture; Tata McGraw Hill; 2012.

List of Experiments:

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

1. Problems on P, PI, PD, PID controllers in MATLAB/SIMULINK.
2. Basic circuits and cylinder sequencing using Fluid Power software & Hardware.
3. Development of virtual instruments using LABVIEW.
4. Design of interfacing circuits using simulation software.
5. Experiments on Programming PLC.
6. Control valve characteristics.
7. Real time temperature/pressure/flow control using PID control system.
8. P/I & I/P converter.
9. Interfacing of any Sensor with Data Acquisition System.
10. Microcontroller based experiments.

ME 6.6 AUTOMOBILE 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	O	P	Total
ME 6.6	Automobile Engineering	3	1	--	3	100	25	--	--	--	**125**

Course Objectives:

1. Understand the need functioning and purpose of various automotive system.
2. Analyze the vehicle performance utilizing the resistances in various scenarios.
3. Applying the engineering knowledge solutions to pollution norms, safety norms and respond to emergent social needs.

Course Outcomes:

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

1. Identify the different components and systems in automobile engineering.
2. Understand and describe importance and features of different systems like axle, differential, brakes, steering, suspension, wheels and transmission.
3. Explain principle of operation, construction and applications of various systems.
4. Understand the need, requirement and functioning of various sensors.

UNIT - 1 (12 Hours)

Introduction: Automobile history and development, Classification, Basic Frame Structure, Sub-frames, Integral and Chassis-less construction, Body styles, Engine and Drive-Train.

Engine Components: Engine Block, Cylinders, Piston and Rings, Connecting Rod, Crankshaft, Bearings, Camshaft, Valve-Train and Valves, Cylinder Head, Combustion chamber, Intake and Exhaust Manifold construction, Oil pan and sump, Gasket and Sealant.

Friction Clutches: Requirement and Operating Principle of friction clutch**,** Clutch components and construction, Cone clutch, Single plate clutch,. Diaphragm spring clutch, Multi-plate clutch, Semi Centrifugal, Centrifugal and Electro-Magnetic clutches. Fluid Flywheel.

UNIT - 2 (12 Hours)

Vehicle Performance: Power for propulsion, Traction and Tractive effort, Road Performance Curves: Acceleration, Gradiability and Drawbar pull.

Gearbox: Necessity of gear box, Sliding Mesh, Constant mesh, Synchromesh, Torque convertor, Epicyclic gear box, Transfer Caseand Four wheel drive system, Overdrive, Automatic Transmission.

Drive Line: Universal joint, Constant Velocity joint,Propeller Shaft, Slip Joint, Differential gears and mechanism, Rear axles.

Tyres and Wheels: Types of tyre construction, Tyre tread, Aquaplaning,Tyre specification, Types of wheels,Wheel construction, alloy wheels.

UNIT - 3 (12 Hours)

Steering System: Condition for true rolling motion, steering geometry, General arrangement of a Steering System, Basic steering Mechanisms: Ackermann and Davis, Types of Steering Gear boxes: Worm and Worm wheel, Worm and Nut, recirculating ball type and Rack and pinion. Over–Steer and Under–Steer, collapsible steering, Tilt steering, Power assisted Power Steering and Electronic power steering.
Wheel Alignment: Principles, Caster angle, Camber angle, King Pin Inclination, Toe-in and Toe out.
Suspension System: Suspension Components, Leaf Spring and Coil Spring, Torsion bar, Telescopic Damper, Independent suspension types: Double wishbone and MacPherson strut, Rear wheel Suspension System: Torque Tube Drive and Hotchkiss Drive. Independent Rear suspension.
Brakes: Functions and Requirements of Brakes**,** Types of brake systems, Theory of shoe brakes, Weight transfer, Drum brake, Self-Energized brakes, Disc brake, Hydraulic Brakes, Parking brakes, Air brakes, Power brakes, Stopping distance.

UNIT - 4 (12 Hours)

Automotive Electrical Systems: Starting system, Battery, Starting Motor. Charging system, Alternator, Ignitions system, Purpose and Requirement, Battery Ignition and Magneto Ignition. Electronic Ignition system
Electric, Hybrid and Fuel Cell Vehicles: Battery Electric Vehicle and Layout, Basic unit of battery electric vehicle, Hybrid Electric Vehicles and Layout, Fuel Cell Vehicle.
Safety Features: Antilock Braking system, Seat belts, Air bags, Traction Control and Stability Control, Crumple Zone, Hill start assistant control, Intelligence Speed Assist, Lane Assist System, parking assistant. Construction, working & application of sensors: temperature sensors, inductive sensors, Position sensors (rotary, linear). Hot wire and thin film air flow sensors, vortex flow/turbine fluid sensors, Optical sensor, Oxygen sensors, Light sensors, Rain sensors.
Drive/ Steer by Wire Automobiles: Introduction, Types and its working.
Automobile Air Conditioning: Introduction, Construction and working**.**

Recommended Readings:

1. K. Singh, Automobile Engineering, Vol I & II, Standard Publishers Distributors; 13e; 2012.
2. K. K. Jain, R. B. Asthana; Automobile Engineering; Tata McGraw Hill; 2002.
3. A. S. Rangwala; Trends in Automobile Engineering, New Age International Publishers; 2017.
4. N. K. Giri; Automotive Mechanics; Khanna Publishers, New Delhi; 2005.
5. M. J. Nunney; Light and Heavy Vehicle Technolog; Elsevier Ltd, 2009.
6. W. H. Crouse, Donald L Anglin Author; Automotive Mechanics; Tata McGraw Hill; 2007.
7. Newton Steeds and Garret; Motor Vehicles; Butterworth, London; 13e, 2005.
8. R. K. Rajput; Automobile Engineering; Laxmi Publications Ltd.; 2017.
9. A. Bonnick, D. Newbold; A Practical Approach to Motor Vehicle Engineering and Maintenance; Routledge Publishers; 2013.
10. A.K. Babu, A.P.Singh; Automobile Engineering; S Chand Publications; 2013.
11. T. Denton; Automobile Electrical and Electronic System; Butterworth Heinemann Publication; 2e; 2003.

Assignments:

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

ME 7.1 HEAT AND MASS TRANSFER

Subject Code	Name of the Subject	Scheme of Instruction Hrs/Week			Scheme of Examination						
						Marks					
		L	T	P	Th Duration (Hrs)	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, e – 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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: Bucking 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, Burmerster 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 RGGR 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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 thermaland 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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 Thermoelectric 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, Thermoelectric, Electrochemical, Chemical Manufacturing Processes, High Energy Rate Forming Processes.
2. Understand various equipments used in the various Mechanical, Thermoelectric, Electrochemical, Chemical Manufacturing Processes and High Energy Rate Forming Processes.
3. Analyze the effect of process parameters in the various Mechanical, Thermoelectric, 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)

Thermoelectric 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						
						Marks					
		L	T	P	Th Duration (Hrs)	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. Practicals 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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						
					Th Duration (Hrs)	Marks					
		L	T	P		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						
					Th Duration (Hrs)	Marks					
		L	T	P		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, Shap-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, Residential stresses and stress gradients, Thermal loading, Heat transfer issues, Basic fluid issues Electrostatics. Couple delectro mechanics. Electromagnatic actuation. Capillary electro-phoresis. Piezoresistive modeling. Piezoelectric modeling. Megntostrictiveactuators. Microsystem Design: Thermomechnical 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 cycler 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/analyt ical 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						
					Th Duration (Hrs)	Marks					
		L	T	P		Th	S	TW	P	O	Total
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, Pearsen Education Asia; 2e; 2001.
2. P. Nageswara Rao; CAD/CAM: Principals 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 Colemon 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, Amonia-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 Psychromerty, 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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 Liquefication 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 Mcmahon 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, Roult'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 nanotsructures 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 ferofluid 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 manufactring. 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 prosesses: 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. Akovali; 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 Concept*s*; 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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 a s 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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						
					Th Duration (Hrs)	Marks					
		L	T	P		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. Gonzalex, 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						
					Th Duration (Hrs)	Marks					
		L	T	P		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.

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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.