ANNEXURE A

SECOND YEAR MECHANICAL ENGINEERING COURSE

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER –III

Course Code	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Duration (Hrs)	Marks					Credits
						Th	IA	TW	P/O	Total	
ME310	Mathematics –III	3	1	--	3	100	25	25	--	150	4
ME320	Mechanics of Solids	4	--	--	3	100	25	--	25	150	4
ME330	Engineering Thermodynamics	4	--	--	3	100	25	--	--	125	4
ME340	Engineering Materials Science and Metallurgy	3	--	--	3	100	25	--	--	125	3
ME350	Engineering Metrology and Machine Drawing	4	--	--	3	100	25	--	--	125	4
ME360	Engineering Materials Science and Metallurgy Laboratory	--	--	2	--	--	--	25	50	75	1
ME370	Engineering Metrology and Machine Drawing Laboratory	--	--	2	--	--	--	25	50	75	1
HM001	Technical Communication	2	--	--	--	--	--	75	--	75	2
AC390	Mathematics I & II (*Bridge Course)	2	--	--	--	--	--	--	--	--	0
	TOTAL	22	1	4	--	500	125	150	125	900	23

*(This course is compulsory to direct second year/lateral entry students. It is introduced to reduce the knowledge gap in the students)

SECOND YEAR MECHANICAL ENGINEERING COURSE

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER –IV

Course Code	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
					Duration (Hrs)	Marks					Credits
		L	T	P		Th	IA	TW	P/O	Total	
ME410	Energy Conversion	4	1	--	3	100	25	25	--	150	5
ME420	Machine Design	4	1	--	3	100	25	25	--	150	5
ME430	Fluid Mechanics	3	1	--	3	100	25	25	--	150	4
ME440	Analysis and Synthesis of Mechanisms	4	--	2	3	100	25	25	--	150	5
ME450	Thermal Laboratory-I	--	--	2	--	--	--	50	50	100	1
ME460	Fluid Mechanics Laboratory	--	--	2	--	--	--	50	50	100	1
HM003	Economics for Engineers	3	--	--	3	100	25	--	25	150	3
	TOTAL	18	3	6	--	500	125	200	100	950	24

THIRD YEAR MECHANICAL ENGINEERING COURSE

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER –V

Course Code	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Duration (Hrs)	Marks					Credits
						Th	IA	TW	P/O	Total	
ME510	Manufacturing Technology-I	4	--	--	3	100	25	--	--	125	4
ME520	Dynamics of Machinery	4	--	--	3	100	25	--	--	125	4
ME531	Advanced Thermodynamics	3	--	--	3	100	25	--	--	125	3
ME532	Mechanical Vibrations										
ME533	Mechatronics										
ME534	Management Information Systems										
ME535	Industrial Safety and Occupational Health										
ME541	Gas Dynamics and Turbo Machinery	3	--	--	3	100	25	--	--	125	3
ME542	Engineering Tribology										
M 543	Advanced Machine Design										
ME544	Micro Electro Mechanical Systems										
ME545	Instrumentation and Control										
ME570	Manufacturing Laboratory	--	--	2	--	--	--	25	50	75	1
ME580	Dynamics of Machinery Laboratory	--	--	2	--	--	--	25	50	75	1
***	Open Elective	3	--	--	3	100	25	--	--	125	3
HM010	Engineering Statistics	3	--	--	3	100	25	--	--	125	3
	TOTAL	20	0	4	--	600	150	50	100	900	22

Students to select ANY ONE subject from ME531, ME532, ME533, ME534, ME535 as Professional Elective - I and ANY ONE subject from ME541, ME542, ME543, ME544, ME545 as Professional Elective - II

LEGEND

Abbreviation	Description
L	Lecture
T	Tutorial
P	Practical
O	Oral
Th	Theory
TW	Term Work
IA	Internal Assessment

THIRD YEAR MECHANICAL ENGINEERING COURSE

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER –VI

Course Code	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Duration (Hrs)	Marks					Credits
						Th	IA	TW	P/O	Total	
ME610	Heat and Mass Transfer	4	- -	--	3	100	25	--	--	125	4
ME620	Manufacturing Technology-II	4	- -	--	3	100	25	--	--	125	4
ME631	Power Plant Engineering	3	- -	--	3	100	25	--	--	125	3
ME632	Advanced Mechanics of Solids										
ME633	Fiber Reinforced Composites										
ME634	Quality and Reliability										
ME635	Applied Operations Research										
ME641	Alternate Energy Sources	3	- -	--	3	100	25	--	--	125	3
ME642	Tool Engineering										
ME643	Fluid Power Control										
ME644	Supply Chain Management										
ME645	System Modeling and Simulation										
ME650	Thermal Laboratory-II	--	- -	2	--	--	--	25	50	75	1
ME660	Manufacturing & Automation Laboratory	--	- -	2	--	--	--	25	50	75	1
***	Open Elective	3	- -	--	3	100	25	--	--	125	3
HM002	Technical English & Report Writing	3	- -	--	3	100	25	--	--	125	3
	TOTAL	20	0	4	--	600	150	50	100	900	22

Students to select ANY ONE subject from ME631, ME632, ME633, ME634, ME635 as Professional Elective - III and ANY ONE subject from ME641, ME642, ME643, ME644, ME645 as Professional Elective - IV

*** Student will have to enter the course code that he/she takes as part of the open elective.

Between 6th & 7th semester - 8 weeks internship/training/research assistantship.

FOURTH YEAR MECHANICALENGINEERING COURSE

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER –VII

Course Code	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Duration (Hrs)	Marks					Credits
						Th	IA	TW	O	Total	
ME710	CAD/CAM	4	--	--	3	100	25	--	--	125	4
ME721	Refrigeration and AirConditioning	3	--	--	3	100	25	--	--	125	3
ME722	Finite Element Method										
ME723	Six Sigma Management										
ME724	Advanced Optimization										
ME725	Additive Manufacturing										
ME730	CAD/CAM Laboratory	--	--	2	--	--	--	25	50	75	1
***	Open Elective	3	--	--	3	100	25	--	--	125	3
ME740	Internship	--	--	6	--	--	--	50	50	100	3
ME750	Project Work-PHASE I	--	--	6	--	--	--	50	75	125	3
	TOTAL	10	0	14	--	300	75	125	175	675	17

Students to select ANY ONE subject from ME721, ME722, ME723, ME724, and ME725 as Professional Elective - V

*** Student will have to enter the course code that he/she takes as part of the open elective.

FOURTH YEAR MECHANICALENGINEERING COURSE

SCHEME OF INSTRUCTION AND EXAMINATION REVISED COURSE 2019-2020

SEMESTER –VIII

Course Code	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
		L	T	P	Duration (Hrs)	Marks					Credits
						Th	IA	TW	O	Total	
ME810	Industrial Engineering and Operations Management	3	- -	--	3	100	25	--	--	125	3
ME821	Energy Conservation and Management	3	- -	--	3	100	25	--	--	125	3
ME822	Automobile Engineering										
ME823	Industrial Automation and Robotics										
ME824	Maintenance Engineering and Management										
ME825	Computational Fluid Dynamics										
ME830	(nptel/mooc/swayam) student can take this online course between 6 to 8 sem. grades will be awarded in 8th sem.	3	- -	--	--	--	--	50	50	100	3
ME840	Project Work- phase II	--	- -	18	--	--	--	200	200	400	9
	TOTAL	9	0	18	--	200	50	250	250	750	18

Students to select ANY ONE subject from ME821, ME822, ME823, ME824, and ME825 as Professional Elective - VI

LEGEND

Abbreviation	Description
L	Lecture
T	Tutorial
P	Practical
O	Oral
Th	Theory
TW	Term Work
IA	Internal Assessment

SECOND YEAR MECHANICAL ENGINEERING SYLLABUS

SEMESTER III

Mathematics - III					
Course Code	**ME310**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**1**	**0**	**(39 + 13) hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

The course is intended at making students understand fundamentals of Mathematics necessary to formulate, solve and analyze engineering problems.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the theory of matrices, Laplace transforms, Fourier Series, Probability theory and the formulation of one dimensional wave equation, heat flow equation and its solution.
CO 2	Compute the rank of matrix, eigen values and eigen vectors of a matrix, Laplace/ inverse transform of functions, Fourier Series of functions and Probability of events.
CO 3	Use rank of a matrix to analyze solutions of linear systems of equations. Solve differential /integral equations using Laplace transforms. Use Fourier series to find the solution of Partial differential equations such as wave equations and heat flow equations.
CO 4	Model real life problems with matrices, use probability for estimation. Propose a value to be substituted in a Fourier series to obtain the given real number series.

UNIT-1	**10 Hrs**
Matrices : Types of matrices, Determinant, inverse of matrix, Elementary transformations, Elementary matrices, Rank of matrix, Reduction to normal form, Canonical form, Rank using elementary transformation, Linear independence and dependence of vectors, System of the form AX = 0, and AX = B, and their solutions, Eigen values, Eigen vectors with properties, Cayley-Hamilton theorem with its applications, Diagonalization.	
UNIT-2	**09 Hrs**
Laplace Transforms: Definition. Existence conditions, properties, inverse Laplace transforms. Laplace transform of periodic functions, Convolution theorem, Laplace transform of Dirac-Delta function, Application of Laplace transforms in solving linear differential equations with initial conditions.	
UNIT-3	**10 Hrs**
Fourier Series : Periodic functions, Trigonometric series, Euler's formulae, Dirichlet's condition, Even and odd functions, Half range series, Parseval's identity. Partial Differential Equations: Derivation and solution of one dimensional wave equation using separation of variable method. Derivation and solution of one dimensional heat equation using separation of variable method.	
UNIT -4	**10 Hrs**
Probability: Definition, properties, Axioms of probability, conditional probability, theorem on total probability, Baye's theorem; Random variables-discrete & continuous; Expectation and Variance, Standard deviation, Moment Generating Function & properties, Standard distributions: discrete-	

Binomial, Geometric & Poisson; continuous- Uniform, Normal, exponential.	

TEXTBOOKS	
1	B. S. Grewal;Higher Engineering Mathematics; Khanna Publications, New Delhi
2	Veerarajan; Engineering Mathematics; Tata McGraw Hill Publications
3	Montgomery, D. C., Probability and Statistics for Engineers; Prentice Hall of India.
REFERENCES	
1	P. Kandasamy; Engineering Mathematics; Chand & Co., New Delhi.
2	Srimanta Pal, Subodh C. Bhunia; Engineering Mathematics; Oxford University Press
3	Erwin Kreyzing; Advanced Engineering Mathematic; New International Limited.
4	D. S. Chandrasekhraiah;Engineering Mathematics- Part III ; Prism Books Pvt. Ltd

MECHANICS OF SOLIDS					
Course Code	**ME320**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**0**	**52 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**25**

Course Objectives:

To identify stress, strain and deformation due to external loads. To perform two dimensional stress and strain analysis. To understand the behavioural response of beams, struts, columns and trusses to forces. To apply various failure theories and energy methods.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic concepts of Stress, Strain, Moment of Inertia, Shear Force and Bending Moment Diagram, Theories of Failure and Energy Methods.
CO 2	Remember the basic relations for Stress, Strain, Moment of Inertia, Pure Torsion, bending of beams, Theories of Failure & Energy Methods.
CO 3	Remember the basic relations for Stress, Strain, Moment of Inertia, Pure Torsion, bending of beams, Theories of Failure & Energy Methods.
CO 4	Analyze structural members and machine elements subjected to axial loads, lateral loads, bending and twisting moments for stresses, strains, and displacements and analyze statically determinate structures using Energy methods

UNIT-1	**14 Hrs**

Introduction: Review of engineering mechanics, static analysis of rigid systems. Introduction to Stress and Strain. Hooke's law, Poisson's ratio, Generalized Hooke's law, modulus of rigidity, bulk modulus, relation between material constants. Uniaxial Deformation: Uniaxial tension and compression, temperature stresses, statically indeterminate systems. Two Dimensional Stress and Strain Analysis: Analysis of two dimensional stress and strain, stress and strain analysis using Mohr's circle, strain gage rosettes.	
UNIT-2	**14 Hrs**
Properties of Areas: Review of Moments of inertia and polar moment of Inertia, Product of inertia, Principal axes, Principal moments of inertia, Mohr's circle for Moment of Inertia. **Beams:** Bending moment and shear force in beams, relation between them, sign convention, Bending stresses in beams- Flexure formula, Shear stresses in beams, deflection of beams (using double integration method, singularity functions method). **Statically Determinate Trusses:** Analysis by method of joints and method of sections in simple statically determinate trusses.	
UNIT-3	**14 Hrs**
Torsion: Torsion of solid and hollow circular shafts. Application of torsion to close and open coiled helical springs. **Theories of Failure:** Various theories of failures and their limitations comparison and applications. **Combined Loading:** Shafts subjected to bending moment and twisting moment, members subjected to bending and direct tension/ compression.	
UNIT -4	**14 Hrs**
Struts and Columns: Struts and core of section, stability of columns, Euler's critical load, for different end conditions of column, empirical formulae for buckling load. **Introduction to Energy Methods:** Strain energy under different loading conditions, Maxwell-Betti reciprocal theorem, Castigliano's theorems, deflection of structures using virtual load method. Theorem of minimum potential energy, complementary strain energy.	
ASSIGNMENTS Four assignments, one on each unit to be submitted within the given deadline.	

TEXTBOOKS	
1	S. Ramamrutham; Strength of Materials; Dhanpat Rai Publishing Co. (P) Ltd.
2	S. S. Bhavikatti; Strength of Materials; Vikas Publishing House Pvt Ltd.
REFERENCES	
1	S. P. Timoshenko, D. H. Young; Elements of Strength of Materials, East West.
2	Beer Ferdinand, Johnson E. Russel; Mechanics of Materials, Mc Graw Hill Books.
3	S. Sreenath; Strength of Materials; Tata McGraw-Hill Education.

ENGINEERING THERMODYNAMICS					
Course Code	**ME330**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**0**	**52 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

To learn the principles of work and energy. To acquire knowledge about the fundamentals of thermodynamic laws, concepts and principles. To understand the principles of various cycles and to apply the thermodynamic concepts in various applications like IC engines and Air conditioning systems

Course Outcomes:

On completing this course students will be able to:

CO 1	Remember the basic concepts, properties, processes, laws, relations, and formulae of thermodynamic systems, pure substance, heat engines and basic energy conversion cycles.
CO 2	Understand the basic concepts, properties, processes, laws, relations, derivations, diagrams, charts and tables of thermodynamic systems, pure substance, heat engines and basic energy conversion cycles.
CO 3	Apply the knowledge of thermodynamics to various applications in engineering and real life.
CO 4	Analyze the various problems associated with thermodynamics in engineering and real life.

UNIT-1	**12 Hrs**
FIRST LAW OF THERMODYNAMICS Internal Energy, Law of Conservation of Energy, First Law of Thermodynamics, Application of First Law to a Process, Energy—A Property of System, Perpetual Motion Machine of the First Kind-PMM1, Energy of an Isolated System, Application of First Law of Thermodynamics to Non-flow or Closed System, Application of First Law to Steady Flow Process, Energy Relations for Flow Process, Engineering Applications of Steady Flow Energy Equation (S.F.E.E.)	
UNIT - 2	**12 Hrs**
SECOND LAW OF THERMODYNAMICS Limitations of First law of thermodynamics, Cyclic devices, Directional constraints, Thermal energy reservoirs. Heat engines, refrigerators/heat pump, Statements – Kelvin- Planck &Clausius, Mathematical interpretations with efficiency, COP, Ton of Refrigeration, Equivalence of statements with illustrations, Perpetual motion machine of second kind, Reversibility and irreversibility – causes and conditions. Carnot Theorems, Absolute temperature scale.	
UNIT-3	**14 Hrs**
ENTROPY Clausius Inequality, Entropy – property, Temperature entropy plane – all standard reversible processes (including polytropic process) with calculation for entropy change on T-S plane, Problem solving & solution procedure. Entropy change - irreversible process, flow processes, concept of lost work, entropy generation – applications, entropy as a measure of disorder. **PROPERTIES OF PURE SUBSTANCE**	

Definition, P-V-T surface, P-V, P-T diagram, T-S diagram of pure substance, h-s diagram or Mollier chart, Quality or Dryness Fraction, Steam tables – Reading and use of various tables & calculations, Measurement of steam quality.	
UNIT-4	**14 Hrs**
VAPOUR POWER CYCLE Simple steam power cycle, Basic Rankine cycle with derivation, mean temperature of heat addition, Work ratio, steam rate, heat rate, Carnot efficiency and comparative analysis, modified Rankine-reheat, regenerative (ideal & actual) with deviation of cycles, derivation & calculation – efficiency. **AIR STANDARD CYCLES** Air standard assumptions, Overview of reciprocating engines, Air standard cycles for reciprocating engines – Otto, Diesel & dual, Criteria for comparison & comparative analysis, Derivation for efficiency, Mean effective pressure (MEP) Brayton Cycle: Ideal cycle for gas turbine engines, Deviation of actual cycle, Enhancement – with regeneration, with reheating, with intercooling	

TEXTBOOKS	
1	Y. A. Cengel, M. A. Boles; Thermodynamics – An Engineering Approach; Tata McGraw Hill Education Pvt. Ltd. New Delhi.4th Ed; 2012.
2	P. K Nag; Engineering Thermodynamics; Tata McGraw Hill Education Pvt. Ltd.; New Delhi.4th Ed.; 2008.
REFERENCES	
1	G. V. Wylen; R. Sonntag, C. Borgnakke; Fundamentals of Classical Thermodynamics; John Wiley & Sons, 4th Ed.; 1996.
2	J. B. Jones, R. E. Dungan; Engineering Thermodynamics; Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Ed.; 1996.
3	E. Radhakrishna; Fundamentals of Engineering Thermodynamics; Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Ed.; 2011.

ENGINEERING MATERIALS SCIENCE AND METALLURGY					
Course Code	**ME340**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

Provide a fundamental knowledge about common engineering materials - metals, ceramics, polymers and composites and the methods of observing, measuring and interpreting these properties, their usage, which are important in engineering design and manufacture. Give familiarity with various characteristics and structure - property relationships and also thermal processing of metals. Provide proficiency and confidence in making judicial material choices for engineering applications.

Course Outcomes:

On completing this course students will be able to:

CO 1	Describe crystal structures and understand the impacts of defects at the atomic and microstructure scales.

CO 2	Interpret phase diagrams, understand the concepts of solid solution and solubility limits, and be able to predict the development of microstructures and impacts of phase transformations.
CO 3	Understand heat treatment of materials and characterisation of material properties.
CO 4	Understand the choice of an alloy for a particular application.

UNIT-1	**11 Hrs**
Crystal Structure: Unit cell, Space lattices and Crystal structures, Packing efficiency, Miller indices for planes and directions, Linear and planar density. **Crystal Defects:** Point defects - vacancy, impurities, Schottky and Frenkel defects. Line defects - edge and screw dislocations, Burgers vector, Dislocation motion, Multiplication of dislocations. Surface defects - grain boundaries, twin boundaries, stacking faults. **Plastic Deformation:** Slip in a perfect lattice, Deformation by slip, Slip systems, Critical resolved shear stress for slip, Deformation by twinning, strain hardening, recovery- recrystallization-grain growth.	
UNIT-2	**10 Hrs**
Phase Diagrams: Solid solutions, Cooling curves, Binary phase diagrams, Gibb's phase rule, Interpretation of phase diagram, Lever rule. **Iron-Carbon Phase Diagrams:** Iron - Iron Carbide diagram, Phases, Structures, Invariant reactions in Fe-Fe_3C diagram, Critical temperature lines and Development of microstructure during slow cooling, Isothermal Transformation diagram and Continuous Cooling Transformation diagram for eutectoid steel. **Cast Irons**: Gray, White, Malleable and Spheroidal Cast Irons.	
UNIT-3	**9 Hrs**
Alloying of Steels: Effect of alloying elements, Classification, Properties and Typical Applications of Alloy steels, Tool steels & Stainless steels. **Heat treatment of steels:** Annealing – Full Annealing, Process annealing and spheroidizing anneal, Normalizing, Hardening, Tempering, Hardenability, Jominy End Quench test. Case hardening of steels - Carburizing, Nitriding, Induction and Flame hardening.	
UNIT -4	**9 Hrs**
Metallography: Sample preparation for micro-structural examination, construction and working of metallurgical microscope. **Mechanical Testing of Materials:** Tensile, Torsion, Impact, Hardness. **Non Destructive Testing of Materials:** X - Ray and Gamma Radiography, Magnetic particle inspection, Fluorescent penetrant test, Ultrasonic inspection, Eddy current inspection. **Other Engineering Materials**: Typical properties, classification and applications of –ceramics, polymers and composite materials.	

TEXTBOOKS	
1	V. Raghavan; Materials Science and Engineering; PHI; Sixth Edition, 2015.
2	William D. Callister Jr.; Materials Science and Engineering; John Wiley & Sons, New York; Sixth Edition, 2003.
REFERENCES	

1	Sydney H. Avner; Introduction to Physical Metallurgy; TMH; Second Edition, 1997.
2	George E. Dieter; Mechanical Metallurgy; TMH, Third edition, 2017.
3	R. A. Higgins; Engineering Metallurgy Part I: Applied Physical Metallurgy; Arnold Publishers; Sixth Edition, 1993.

ENGINEERING METROLOGY AND MACHINE DRAWING					
Course Code	**ME350**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**0**	**52 hrs/sem**	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**0**

Course Objectives:

To visualize mechanical component and convert it into a drawing. To understand conventional symbols used in machining and mechanical details as per IS. To assemble and disassemble the mechanical parts.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand basic principles and standards of engineering measurements
CO 2	Understand the use of limits, fits, tolerances, GD&T in Mechanical engineering
CO 3	Create assembly drawings and freehand sketches of mechanical joints / fasteners.
CO 4	Create disassembly drawings and freehand sketches of permanent joints.

UNIT-1	**12 Hrs**
Basic Principles of Engineering Measurement: Introduction to Metrology, Need for Inspection, Objectives of Metrology and Measurements, Process of Measurement, Accuracy and Precision, Calibration of Measuring Instruments, Errors in Measurements, Systematic and Random Errors, Methods of Measurement. **Standards of Measurement:** Introduction, Standards and their Roles, Systems of Measurement, Material Standard, Wavelength Standard, Line and End Standards of Measurements, their characteristics, advantages and disadvantages. **Linear Measurement:** Depth gauge, height gauge, Vernier Instruments, Micrometer Instruments, and Slip Gauges: Sizes and Grades, Wringing, building up of slip gauges for required dimension, care of slip gauges. **Angular Measurement:** Bevel Protractor, Sine Bars, Angle gauges and its combination to build the required angle	

UNIT-2	**14 Hrs**
Dial Indicators: Requirement of good dial indicator, classification, advantages and limitations. **Comparators:** Classification, need, essential characteristics of a good comparator, classification. Advantages, Limitations and Applications: Mechanical, Optical, Electrical, Electronic, Pneumatic. **Limits, Fits, and Tolerances:** Introduction, Tolerances, classification of tolerances, clearance, interference and transition Fits, allowance, System of Limits and Fits, Indian Standard limit fit system, Limit gauging, classification of gauges, Taylor's Principle of Gauge Design, Gauge Tolerance, Wear Allowance, Design of Plug and Snap gauges. **Geometric Tolerancing:** Introduction, types: form, orientation, positioning and run out, symbolic	

representation of geometric tolerances, symbols on a standard drawing and their interpretation. **Metrology of Screw Threads:** Measurement of Screw Thread elements: Major diameter, Minor diameter, measurement of Pitch. **Metrology of Surface Finish**: Concepts, Terminology, Analysis of Surface traces, surface texture symbols. Tomlinson Surface Meter, Taylor-Hobson Talysurf.	
UNIT-3	**13 Hrs**
Preliminaries: Introduction to machine drawing, conventional representation of machine components, materials, springs & gears. **Threaded Fasteners & Joints**: Screw thread nomenclature, types of threads, nut, bolt and washer, locking arrangements of nuts, foundation bolts (freehand sketches only) **Keys, Cotters & Pin Joints:** Keys, cotter joints, socket & spigot joint, sleeve & cotter joints, jib & cotter joint, knuckle joint (freehand sketches only) **Assembly Drawings with Sectioning and Bill of Materials (only front view):** Footstep bearing, Lathe tool post, screw jack, pipe vice.	
UNIT-4	**13 Hrs**
Part or Disassembly Drawings: Milling Machine Tail stock, crane hook, blow off cock, feed check valve.	

TEXTBOOKS	
1	R. K. Jain; Engineering Metrology; Khanna Publishers; 21e; 2015.
2	N. Siddheshwar, P. Kannaiah, V. V. S. Sastry; Machine Drawing; Tata-McGraw Hill.
3	K. C. John; A text book of Machine Drawing; PHI Learning Pvt. Ltd., New Delhi.
REFERENCES	
1	N. V. Raghavendra, L. Krishnamurthy; Engineering Metrology and Measurements; Oxford University Press; 2015.
2	P. S. Gill; Machine Drawing; SK Kataria& Sons, New Delhi.
3	N. D. Bhat; Machine Drawing; Charotar Publishing Company.

ENGINEERING MATERIALS SCIENCE AND METALLURGY LABORATORY

Course Code	**ME360**		**Credits**	**1**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**2**	**26 hrs/sem**	
Scheme of Examination TOTAL = 75 marks	**IA**	**TW**	**TM**	**P**	**O**
	0	**25**	**0**	**50**	**0**

Course Objectives:

To study the microstructure and mechanical properties of metallic materials, to check the presence cracks & flaws in materials and to conduct the heat treatment procedures on steel.

Course Outcomes:

On completing this course students will be able to:

CO 1	Determine the mechanical properties of a given material such as hardness, impact strength, tensile properties, creep and fatigue strength
CO 2	Analyse micrograph of given metallic material and correlate the effect of heat treatment on microstructure

LIST OF EXPERIMENTS	

Eight experiments to be conducted from the below given list of experiments. To draw the stress-strain curve and calculate the elastic limit, yield strength, ultimate tensile strength, percentage of elongation, percentage of reduction in area, toughness and resilience of the given metal. To measure the hardness of the given material using Brinell/Rockwell/Vicker's Hardness testing machine. To measure the impact strength and notch sensitivity of the given metal. To study the creep behavior and determine the steady state creep rate of the given specimen To determine the capacity of the material to withstand repeated cyclic stress through fatigue test. To determine the ductile - brittle transition temperature of the given metal. To determine the formability of the given metal using cupping test. To study the microstructure of (a) mild steel (b) brass (c) cast iron. To detect the presence of cracks/flaws in the given metal piece by magnetic particle crack detection method. To detect the presence of cracks/flaws in the given metal piece by dye penetrant test. To determine the hardenability of the given specimen using Jominy End Quench test. To study the change of microstructure and property during heat treatment of the given specimen. To determine the wear constant of the given material using wear testing machine To determine the torsional strength and angle of twist of the given specimen	

ENGINEERING METROLOGY AND MACHINE DRAWING LABORATORY					
Course Code	**ME370**		**Credits**	**1**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	0	**0**	**2**	**26hrs/sem**	
Scheme of Examination TOTAL = 75 marks	**IA**	**TW**	**TM**	**P**	**O**
	0	**25**	**0**	**50**	**0**

Course Objectives:

1. To inculcate in students the habit of giving importance to metrology and measurement and to apply measurement concepts in real-world situations.
2. To possess knowledge of the sources of measurement errors and how their influence may be reduced.
3. To read and understand the geometric representations and conventional symbols used in machining and mechanical details as per IS on the drawing.
4. To visualize mechanical component and convert it into a drawing.
5. To gain knowledge in two dimensional drafting and to assemble and disassemble the mechanical parts.

Course Outcomes:

On completing this course students will be able to:

CO 1: Remember the various standards of measurement, basic principles with applications of various measuring instruments &comparators and the geometric representations and conventional symbols as per IS used in machining drawing.

CO 2: Understand the sources of measurement errors and how their influence may be reduced, use of measuring instruments and comparators, limits, fits, tolerances, GD&T in Mechanical engineering and applications of threaded fasteners, keys & Joints.

CO 3: Apply the knowledge in doing various measurements and create assembly/disassembly drawings and freehand sketches of mechanical joints & fasteners.

CO 4: Analyze and interpret the readings, assembly/disassembly drawings and tolerances and conventional symbols as appearing on drawing sheets.

LIST OF DRAWING SHEETS	
Following should be completed and submitted within given deadline. **Two** sheets on assembly and **two** sheets on disassembly to be done. **One** drawing on assembly and disassembly to be done using AutoCAD or any other standard drafting software. Sketch book to comprise of free hand sketches. (Unit 3 and Unit 4) **(Term work marks allotted for the above = 15)**	
LIST OF EXPERIMENTS	
Five experimentsto be conducted from the below given list of experiments. MeasurementbyUsingVernierCalliper(Dial,DigitalandPlain). MeasurementofdimensionsusingVernierHeightGauge. MeasurementofdimensionsusingMicrometerScrewGuage(DigitalandPlain). Calibration of Vernier Calliper (Dial, Digital, Plain) by using Slip Gauges. Calibration of Micrometer (Digital, Plain) by using Slip Gauges. MeasurementofangleusingSinebar/Sinecenter. Measurement of Angle using BevelProtractor. Measurement of Angle using HeightGauge. Use of Dial GaugeasMechanicalComparator. MeasurementofSurfaceRoughnessusingSurfaceRoughnessTester. Measurement of various elements of screw thread using Tool Makers Microscope. MeasurementofScrewthreadparametersusingFloatingCarriageMicrometer. LinearandangularmeasurementusingProfileProjector. (Term work marks allotted for the above = 15) The Term Work marks to be awarded based on the assessment of the completed sheets, soft copy of drawing using drafting software, the sketch book and the assessment of the file containing minimum six experiment from the list of experiment given above	

TECHNICAL COMMUNICATION					
Course Code	**HM001**		**Credits**	**2**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	2	**0**	**0**	**26 hrs/sem**	
Scheme of Examination TOTAL = 75 marks	**IA**	**TW**	**TM**	**P**	**O**
	0	**75**	**0**	**0**	**0**

Course Objectives:

To acquaint the students with basic concepts, theories and barriers to communication. To enhance communication skills by giving adequate exposure in LSRW skills and interpersonal skill. To build multidisciplinary approach towards life tasks and life learning.

Course Outcomes:

On completing this course students will be able to:

CO 1	Demonstrate precise language skills with suitable vocabulary and apt style.
CO 2	Develop life skills/interpersonal skills to progress professionally
CO 3	Apply traits of suitable candidature for a job/higher education.
CO 4	Deliver formal presentations and effectively implementing the verbal and non-verbal skills.

UNIT -1	**7 Hrs**
Communication **Oral Communication** Listening, Speaking, Reading, Writing (LSRW), Conversational Dialogues, Role Play, Barriers to Oral Communication, Effective Oral Communication, Principles of Communication, Dos and Don'ts of Group Discussion **Global Communication** Social Media, People Analytics, Models of Culture, Cross-Cultural Communication, Compare Cultures of the World, Impact of Cultural Differences on Managerial Communication, Effective Communicator in a Cross-Cultural setting	
UNIT -2	**7 Hrs**
Personality Development Social Etiquette, Email Etiquette, Table Etiquette, Telephone Etiquette, SWOC Analysis, Life Coaching, Emotional Intelligence, Leadership, Time Management, Motivation, Goal Setting, Team Work and Collaboration, Critical Thinking and Problem Solving, Professional Attitude, Persuasion, Anxiety and Stress Management, Social Responsibility	
UNIT -3	**6 Hrs**
Career Development Resume Building, Interviewing Skills, Job Search, Personal Networking and Branding, Personal Finance, Build Professional Portfolio	
UNIT -4	**6 Hrs**
Public Speaking Methods to overcome anxiety, Build Confidence, Use of Media Aids, Craft an Impactful Speech, Design Impactful Presentations, Effective Presentation Delivery	

TEXTBOOKS	
1	Meenakshi Raman and Sangeeta Sharma; Technical Communication: Principles and Practice, 3rd ed; Oxford University Press
2	Meenakshi Raman, Prakash Singh; Business Communication; 2nd ed.; Oxford University Press

3	Dr. K. Alex; Soft Skills: Know Yourself and Know The World; 3rd ed; S. Chand Publishing
REFERENCES	
1	Nicky Stanton; Mastering Communication; 5th ed.; Palgrave Master Series; Red Globe Press
2	Ghosh, B. N.; Managing Soft Skills for Personality Development; Tata McGraw Hill; 2012
3	Wallace and Masters; Personal Development for Life and Work;10th edition; Thomson Learning
4	Lehman, Dufrene, Sinha; BCOM : A South-Asian Perspective with CourseMate; 2nd edition; Cengage Learning
5	Ashraf Rizvi; Effective Technical Communication; Tata McGraw-Hill; 2005
6	MolefiKete Asante, William B. Gudykunst, Bella Mody; Handbook of International and Intercultural Communication; 2nd ed.; Sage Publications

MATHEMATICS-I& II (BRIDGE COURSE)					
Course Code	**AC390**		**Credits**	**0**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	2	**0**	**0**	**26 hrs/sem**	
Scheme of Examination TOTAL = 0 marks	**IA**	**TW**	**TM**	**P**	**O**
	0	**0**	**0**	**0**	**0**

Course Outline:

This is an audit course.

This course is compulsory to direct second year/lateral entry students. It is introduced to reduce the knowledge gap in the students.

The syllabus is selected topics from FE110 Mathematics I and FE120 Mathematics II.

The Text books and References are same as shown in FE110 Mathematics I and FE120 Mathematics II.

SEMESTER IV

ENERGY CONVERSION					
Course Code	**ME410**		**Credits**	**5**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**1**	**0**	**52 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

To study the air standard and actual engine cycles. Study of SI and CI engine components and processes involved along with engine performance characteristics and emissions. Study of alternate fuels for IC engines.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the construction and operation of engine with alternate fuels used and modern trends in IC Engines

CO 2	Illustrate principle of combustion, concepts of fuel air and Actual Cycles
CO 3	Analyse Performance characteristics of the engine, supercharged and turbocharged engines.
CO 4	Evaluate performance and emissions of IC Engines

UNIT-1	12 Hrs
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 **Actual Cycles & Their Analysis:** Introduction, Comparison of thermodynamic & Actual Cycles, various losses. **Fuels:** Important qualités of the Engine fuels - (SI & CI engines), Alternate fuels (SI & CI engines)	
UNIT-2	**12 Hrs**
Spark Ignition Engines: Theory of Carburetion, Types of carburetors, Electronic fuel injection system, GDI, MPFI, 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, . Rating of fuels in SI engines, Additives. **Compression Ignition Engines:** Fuel supply system, types of fuel pump, injector and distribution system, Combustion in compression ignition engines, stages of combustion, factors affecting combustion, Phenomenon of knocking in CI engine. Effect of knocking, rating of fuels in CI engines. Dopes & Additives, Comparison of knocking in SI & CI engines.	
UNIT-3	**14 Hrs**
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. . **Emission of I.C. Engines:** Air pollution due to IC engine, Engine emissions, Hydrocarbon emissions, (HC) & 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, Cat con, EGR. Modern Trends in I.C. Engines	
UNIT -4	**14 Hrs**
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 & simple numericals on super & turbocharged engines. **Alternative Potential Engines:** VCR engine, Dual fuel engines, Multi fuel engines, concept of hybrid vehicles, Modern Trends in I C Engines.	

TEXTBOOKS	
1	Internal Combustion Engine, V Ganesan - TataMcGraw Hill
2	Internal Combustion Engine, Mathur and Sharma

3	Power Plant Engineering, P.K.Nag, McGraw Hill Publications New Delhi.
REFERENCES	
1	Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education.
2	Thermal Engineering, .R.K.Rajput, Laxmi Publications New Delhi.
3	Power Plant Engineering, Domkundwar& Arora, Dhanpat Rai & Sons, New Delhi.

MACHINE DESIGN					
Course Code	**ME420**		**Credits**	**5**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**1**	**0**	**(52+13) hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

The student will achieve an understanding of the design process in mechanical engineering and will be able to correlate design with manufacturing. Understand and be able to design various types of machine elements.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic principles for designing machine elements and joints subjected to Static and Fatigue loading.
CO 2	Comprehend and apply mathematical relations for designing machine elements and joints.
CO 3	Calculate the dimensions of machine elements and joints subjected to static and dynamic loading
CO 4	Analyze the problems related to static and fatigue loading of machine components and selection of drives for given applications.

UNIT-1	**14 Hrs**
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 socket and spigot type of cotter joint and knuckle joint. Design of levers viz. hand / foot lever, bell crank lever, lever for safety valve. Design of curved members with rectangular, circular, trapezoidal and I sections. **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 and Gerber criteria in designing for alternating stresses. Modified Goodman diagram. Design of components for fatigue under combined stresses.	
UNIT-2	**14 Hrs**
Design of Shafts, Keys & Couplings: Design of shaft based on strength, torsional rigidity and lateral rigidity. Design of shaft based on A.S.M.E. code. Classification of keys, Design of Parallel, Taper Sunk	

keys, Woodruff key and Splines. Classification and objectives of couplings, Design of rigid Flanged Coupling and Flexible Bushed Pin Coupling. **Design of Threaded Joints:** Threaded connections: screw fastener classification, Terminology of ISO metric threads, Bolted joint in tension, Eccentrically loaded threaded joints. **Design of Welded Joints**: Stresses in fillet & Butt welds. Strength of Parallel & Transverse fillet weld, Eccentrically loaded welded joints, Weld joints subjected to bending and twisting moments.	
UNIT-3	**14 Hrs**
Springs: Types, application and material for springs, Design equations for helical compression springs, styles of ends, Design of Helical Compression and Tension Springs, helical concentric springs. **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. Power transmission using Wire ropes (theoretical treatment only), types of chains, Power transmission using Chains (theoretical treatment only)	
UNIT -4	**10 Hrs**
Gear Design: 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.	

TEXTBOOKS	
Design of Machine Elements, Bhandari V. B., Tata McGraw-Hill Education. Mechanical engineering Design, Shigley J. E., McGraw-Hill Publication.	
REFERENCE BOOKS	
Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series. C.S.Sharma and KamleshPurohit, Design of Machine Elements, PHI Learning Pvt. Ltd. D.K.Aggarwal&P.C.Sharma, Machine Design, S.K Kataria and Sons Design Data - P.S.G. College of Technology, Coimbatore. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers. Design of Machine Elements, Spotts M. F., Shoup T. E., Prentice Hall International. Peter Childs, Mechancial Engineering Design R.L.Norton, Machine Design, Pearson Education. **Note:** Only Reference Books at No. 4 and 5 to be used as data books in semester examination. These reference books (Data Books) at 4 and 5 above are to be provided by the College Examination Cell. Students should not be allowed to carry their own data books in the examination hall.	

FLUID MECHANICS					
Course Code	**ME430**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**1**	**0**	**(39+13) hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

To understand fluids, its properties and fluid statics.To analyze Kinematics and Dynamics of fluid flow.To understand the concept of buoyancy and viscous flow.To study boundary layer concept.

Course Outcomes:

On completing this course students will be able to:

CO 1	**Understand** the basic concept of fluid flow and properties of fluids
CO 2	**Understand** the principles of fluid statics, kinematics and dynamics
CO 3	**Analyse** fluid flow problems with the application of the momentum and energy equations. Understand concept of buoyancy, viscosity and importance of viscosity in real flows
CO 4	Perform dimensional analysis for problems in fluid mechanics. **Understand** the concept of boundary layer formation.

UNIT-1	**10 Hrs**
Properties of Fluids: Basic concepts and definitions, Classification and properties of fluids, Surface tension and capillarity, Compressibility and bulk modulus. **Fluid Statics:** Liquid pressure and its types, Pascal's law, Pressure variation in a static fluid, Measurement of pressure, Manometers (simple), Differential manometers, Mechanical gauges **Hydrostatic Forces on Surfaces:** Total pressure, Center of pressure on vertical submerged surfaces in liquid, Total pressure, Center of pressure on horizontal & inclined submerged surfaces in liquid, Hydrostatic paradox.	
UNIT-2	**10 Hrs**
Fluid Kinematics & Dynamics: Types of fluid flow, Discharge, continuity equation, Continuity equation in 3D, Equations of motion, Euler's equation, Bernoulli's equation, Practical application of Bernoulli's equation, Impulse momentum equation, Kinetic energy and momentum correction factor. **Flow through Pipes:** Loss of head in pipes, major, minor losses, Darcy's Weisbach equation, Hydraulic gradient and total energy line, Flow through siphon , Equivalent pipe -series & parallel pipes, Flow through nozzle, Water hammer in pipes.	
UNIT-3	**09 Hrs**
Buoyancy: Buoyancy, Centre of Buoyancy, Conditions of equilibrium of floating & submerged bodies, Meta-centre and Metacentric height. **Viscous Flow**: Introduction, Reynold's experiment, Flow of viscous fluid through circular pipe-Hagen Poiseuille formula, Flow of viscous fluid between two parallel plates, Power absorbed in viscous flow: Viscous resistance of journal bearing, Foot-step bearings, Collar bearings, Loss of head due to friction in viscous flow	
UNIT -4	**10 Hrs**
Dimensional Analysis: Dimensions of physical properties, Dimensional homogeneity, Buckingham's pi theorem, Raleigh's method, Important dimensionless numbers. **Boundary layer:** Laminar and turbulent boundary, Laminar sub layer, Boundary layer thickness, Energy thickness and momentum thickness, Drag force on a flat plate due to boundary layer, Total drag due to laminar and turbulent layers, Boundary layer separation and its control.	

TEXTBOOKS	
1	R. K. Bansal; A textbook of Fluid Mechanics & Hydraulic machines; Laxmi Publications (p) Ltd; 2012.

2	D. S. Kumar; Fluid Mechanics & Fluid Power Engineering; S. K. Kataria& sons, New Delhi; 2008.
3	P. N. Modi, S. M. Seth; Hydraulics & Fluid Mechanics including Hydraulic Machines; Standard Book House, New Delhi; 2009.
REFERENCES	
1	Y. A. Cengel, J. M. Cimbala; Fluid Mechanics: Fundamentals & Applications; TMH, New Delhi; 2/e.
2	R. W. Fox, P. J. Pritchard, A. T. McDonald; Introduction to Fluid Mechanics; Wiley India; 7/e.

ANALYSIS AND SYNTHESIS OF MECHANISMS					
Course Code	**ME440**		**Credits**	**5**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**2**	**(52+26) hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

Aims at initiating, Mechanical Engineering students, in the area of synthesis and analysis of the mechanisms. To analyse mechanical systems, in general. Familiarize basic concepts of toothed gearing and kinematics of gear trains.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand fundamental concepts in the study of mechanisms and analyse the motion of commonly used linkages.
CO 2	Analyse linkages for position, velocity and acceleration using analytical and graphical methods.
CO 3	Synthesize linkages to produce predetermined motion using analytical and graphical methods.
CO 4	Design and analyse cams, gears, and gear trains.

UNIT-1	**13 Hrs**
Classification of Mechanisms: Basic kinematic concepts and definitions, degree of freedom, mobility, Kutzbach's criterion, Gruebler's criterion, Grashof's Law, kinematic inversions of four-bar chain and slider crank chains, limit positions, mechanical advantage, transmission angle. **Description of some Common Linkages:** Exact and approximate straight-line mechanisms, steering gear mechanisms, Geneva wheel mechanism, ratchet and pawl mechanism, toggle mechanism, pantograph and universal joint. **Kinematics of Rigid Body:** Mathematical preliminaries on vectors & matrices, fixed and moving reference frames, coordinate transformations, displacement, time derivatives, angular	

velocity and acceleration, velocity and acceleration analysis using moving reference frame, Chasles' theorem.	
UNIT-2	**13 Hrs**
Velocity and Acceleration Analysis of Mechanisms: Displacement, velocity and acceleration analysis of mechanisms having higher and lower pairs, by graphical and analytical methods, instantaneous centre of velocity, Aranhold Kennedy theorem, angular velocity ratio theorem, kinematic analysis by algebraic methods, vector approach, Klein's construction, Coriolis acceleration.	
UNIT-3	**13 Hrs**
Kinematic Synthesis of Planar Mechanisms: Task of synthesis and it's classification, synthesis of mechanism for three accuracy points using graphical and analytical techniques, Freudenstein's equation, Four bar coupler curves, Cognate linkages, Bloch's synthesis method, Practical consideration in mechanism synthesis. **Cams:** Different types of Cams and followers and terminology for Cam- follower Mechanisms: follower motions : uniform velocity, uniform acceleration and retardation , SHM and cycloidal, their comparison, graphical synthesis of cam profile for a given follower and it's motion, 3-4-5 polynomial cams.	
UNIT -4	**13 Hrs**
Spur Gears: Introduction, classification of gears, gear terminology, law of gearing, velocity of sliding, forms of teeth, cycloidal profile teeth, involute profile teeth, path of contact, arc of the contact, numbers of pairs of teeth in contact, interference in involutes gears, minimum number of teeth to avoid interference, interference between rack and pinion, under cutting, method of avoiding interference, non- standard gears, comparison of cycloidal and involute tooth forms. **Gear Trains:** Analysis of simple, compound and epicyclic gear trains.	

ASSIGNMENTS	
Four assignments, one on each unit to be submitted within the given deadline.	

TEXTBOOKS	
1	S.S. Rattan; Theory of Machines; McGraw-Hill Education (India) Pvt Ltd.
2	J. S. Rao, R. V. Dukkipati; Mechanism and Machine Theory; Wiley Eastern Limited
3	Irving H. Shames; Engineering Mechanics; Prentice Hall of India Pvt. Ltd.
REFERENCES	
1	Jospeh E. Shigley, John J. Uicker Jr.; Theory of machines and Mechanisms; McGraw Hill International.
2	Hamilton H. Mabie, F. Charles F. Reinholtz; Mechanism and Dynamics of Machinery; John Wiley & Sons.
3	George H. Martin; Kinematics and Dynamics of Machines; McGraw-Hill International.
4	Waldron, Kenneth J., Gary L. Kinzel, and Sunil K. Agrawal. Kinematics, dynamics, and design of machinery. John Wiley & Sons, 2016.

THERMAL LABORATORY-I			
Course Code	**ME450**	**Credits**	**1**

Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	26 hrs/sem	
Scheme of Examination TOTAL =100 marks	IA	TW	TM	P	O
	0	50	0	50	0

Course Objectives:

1. This course aims to provide a good platform to mechanical engineering students to understand, model and appreciate concept of dynamics involved in thermal energy transformation.
2. To prepare them to carry out experimental investigation and analysis at later stages of graduation.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the knowledge of mathematics, science and engineering fundamentals to model the energy conversion phenomenon
CO 2	Apply the knowledge of mathematics, science and engineering fundamentals to study Internal Combustion Engines and Turbomachines
CO 3	Analyze performance of Internal Combustion Engines, Turbomachines and Boiler
CO 4	Evaluate performance parameters of Internal Combustion Engines and Turbomachines

LIST OF EXPERIMENTS	
Part A: Study of physical systems in terms of constructional details and functions 1] 2 Stroke and 4 Stroke Engines 2] Carburetor. 3] Ignition system. 4] Fuel injection system. 5] Reciprocating Compressor 6] Boilers **Part B: Students shall perform at least 5 experiments from the list** Performance Test on Four stroke Petrol Engine Performance Test on Four stroke Diesel Engine Emission Analysis of Petrol Engine Emission/ smoke Analysis of Diesel Engine Performance Test on Reciprocating Compressor Operating/main characteristics of Kaplan Turbine. Operating/main characteristics of Pelton Wheel. Operating/main characteristics of Francis Turbine Performance Analysis of Boiler.	

FLUID MECHANICS LABORATORY					
Course Code	ME460		Credits	1	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	26 hrs/sem	
Scheme of Examination TOTAL =100 marks	IA	TW	TM	P	O
	0	50	0	50	0

Course Objectives:

The students will learn to conduct experiments to verify fundamental principles of fluid mechanics, calibrate measuring devices, analyze experimental data and develop empirical relations when appropriate.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand working and principle of flow rate measuring devices in closed conduit. Distinguish the constructional differences between orifice meter and venturimeter.
CO 2	Understand working and principle of flow rate measuring devices in open channels.
CO 3	Experimental measurement of coefficient of friction and losses in fluid system.
CO 4	Understand effect of metacentric height on stability of Floating body and forces on submerged body.

LIST OF EXPERIMENTS	
Eight experiments to be conducted from the below given list of experiments. Verification of Bernoulli's Theorem To determine the coefficient of discharge of a venturimeter To determine the coefficient of discharge of a orifice meter Calibration of a rotameter To determine the coefficient of discharge of a mouthpiece To determine the coefficient of discharge of a V- notch To determine the coefficient of discharge of a Rectangular- notch To calculate friction factor in Helical coil To determine coefficient of friction in pipe set-up To find minor losses in pipes To determine the coefficient of discharge of a flow nozzle Demonstration of Reynold's Experiment Determination of metacentric height of a ship model Determination of the centre of pressure of a plane surface being subjected to hydrostatic thrust Experimental verification of momentum equation Study of boundary layer velocity profile	

ECONOMICS FOR ENGINEERS					
Course Code	**HM003**		**Credits**	**3**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**0**	**39 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**25**

Course Objectives:

1. To expose students to basic Economic concepts and apply economic reasoning to problems of business.
2. To familiarize the students with the microeconomics principles of economics.

3. To enhance students understanding of macroeconomic issues and problems.

4. To acquaint the students with standard concepts that they are likely to find useful in their profession when employed.

Course Outcomes:

On completing this course students will be able to:

CO1	Understand the basic principles of economics, micro behaviour of consumer & firms in different market structures, various macroeconomic policies, aspects of financial market & measures of Economic Growth and Development.
CO2	Apply the basics of economics, costs concepts in decision making.
CO3	Analyze the macroeconomic concepts & their relation to microeconomic concept & how they affect the business and economy. Assess the measures of Economic Growth and Development
CO4	Evaluate economic theories, principles of economics, cost concepts, market structures, measures of National Income and assess its impact on economic growth and development. Make economically sound decision.

UNIT 1	
Central concepts of Economics- Definitions of Economics , Scarcity and Efficiency, Nature of Economics: Positive and normative economics, Microeconomics and Macroeconomics Basic Elements of Supply and Demand- The Demand Schedule, The Demand Curve, Market Demand , Forces behind the Demand Curve, Shifts in Demand. The Supply Schedule The Supply Curve, Forces behind the Supply Curve , Shifts in Supply. Equilibrium of Supply and Demand, Effect of a Shift in Supply or Demand. Supply and Demand: Elasticity and Applications to major economic issues **Estimation/Forecasting of Demand:** Meaning, importance, methods – trend, exponential smoothing, regression analysis	**11 Hours**
UNIT 2	
Microeconomics: Demand & Consumer Behaviour- Choice & Utility Theory. Production and Business Organization, Theory of Production and Marginal Products Basic Concepts, The Nature of the Firm, Big, Small, and Infinitesimal Businesses. Economic Analysis of Costs, Total Cost: Fixed and Variable. Production, Cost Theory, and Decisions of the Firm.	**09 Hours**
UNIT 3	
Macroeconomics: Key Concepts of Macroeconomics. Objectives and Instruments of Macroeconomics. Aggregate Supply and Demand. **National Income Terms:** -Gross Domestic Product: The Yardstick of an Economy's Performance. Real vs. Nominal GDP. Net Domestic Product, GNP, National Income, Per capita income, Disposable Income, Price Index, Inflation. Monetary Policy and the Economy .Government Control of the Economy- The Tools of Government Policy	**09 Hours**
UNIT 4	

Economic Growth and Development: Economic Growth- The Long-Term Significance of Growth, The Four Wheels of Growth. Economic Development- meaning, criteria, measures of development- Per Capita Income, Index of Human Development . Financial markets- Structure, Participants, functions. Capital market- Instruments, Players, trading - Primary and secondary market - Role of stock exchanges and stock indices. Money market	**10 Hours**

TEXTBOOKS	
1	P.A. Samuelson & W.D. Nordhaus, Economics, 19th Edition McGraw Hill, New York, 1995.
2	A. Koutsoyiannis, Modern Microeconomics, Macmillan, 1975.
3	O.P. Khanna , Economics for Engineers,VK Global Publications Private Limited.
REFERENCES	
1	Chandra P., Fundamentals of Financial Management, Tata McGraw Hill Education Private Limited, New Delhi

ANNEXURE C

THIRD YEAR MECHANICAL ENGINEERING SYLLABUS

SEMESTER V

(Prof. Core-9) MANUFACTURING TECHNOLOGY – I

Course Code	ME510		Credits	4	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	4	0	0	56 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To introduce basic manufacturing processes: casting, metal forming, welding and plastic processing.
2. To introduce jigs and fixtures, their types and applications.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the principles of Casting, welding, forming processes and processing of plastics.
CO 2	Select the appropriate manufacturing processes for a given product.
CO 3	Compute the process parameters for casting and metal forming.

CO 4	Apply the knowledge of jigs and fixtures for turning and milling applications.

UNIT-1	14Hrs
Casting: Basic steps in making sand moulds, advantages of casting. Pattern: Materials, types, pattern making allowances. Core: Functions, types, core boxes, core making, core print, chaplets. Moulding Sand: Moulding sand composition, general properties of moulding sand, sand testing (analytical treatment), green sand moulds, dry sand moulds. Electric Furnaces for Melting Iron & Steel: Construction & operation. Special Moulding and Casting Processes: CO2 Moulding, Shell Moulding, Plaster Mould Casting, Investment Casting, Centrifugal Casting-True, Semi and Centrifuging. Pressure Die Casting-Hot Chamber & Cold Chamber. Casting Design: Pouring and Feeding, Progressive and Directional Solidification, Typical Gating System and its Elements, Gates and Risers. Casting Defects	
UNIT-2	14Hrs
Welding: Advantages, Classification and Types of Welds. Edge preparation for butt welds, Weldability and Metallurgical aspects of Welding. Thermit Welding: Advantages, Disadvantages and Applications. Gas Welding: Oxy-Acetylene Gas Welding, Types of Flames, Welding techniques, Welding equipment's. Arc Welding: Submerged Arc Welding (SAW), Tungsten Inert Gas Welding (TIG), Metal Inert Gas Welding(MIG), Under Water Welding. Resistance Welding: Spot, Seam Projection, Upset Butt, Flash Butt, Percussion , High Frequency. Brazing and Soldering: Advantages and Applications. Solid State Welding: Smith, Cold Pressure, Friction, Explosive, Diffusion. Radiant Energy Welding: Laser Beam Welding (LBW), Electron Beam Welding	
(EBW), Ultrasonic Welding (USW).	
UNIT-3	14Hrs
Metal Forming: Theoretical basis and analysis of Metal Forming, Classification of Forming Processes, Hot and Cold Working, Explosive Forming, Electromagnetic Forming, Effect of variable on Metal Forming. Rolling: Types of Rolling Mills, Roll Product Technology, Force and Power Calculation. Forging: Classification-Open Die and Closed Die Forging, Hammer and Press Forging, Hand and Machine Forging, Force Calculation, Advantages and Disadvantages of Forging. Extrusion: Direct, Indirect, Impact, Hydrostatic. Drawing -Wire & Tube. Drawing Die and its Construction, Protective Metallic Coatings	
UNIT -4	14 Hrs

Fabrication of plastics: Casting-Hot Compression Moulding, Transfer Moulding, Injection Moulding, Blow Moulding, Extrusion, Thermoforming, Calendering, Machining and Joining of Plastics. Jigs and fixtures: Introduction, Definitions, Elements, Principles of Location, Types of Locaters, Clamps, Jig Bushes, Types of Jigs-Template, Plate, Channel, Leaf, Box. Types of Fixtures, Turning, Milling, Component based applications of Jigs and Fixtures .	

TEXTBOOKS	
1	P. N. Rao; Manufacturing Technology, Volume- I; Tata McGraw Hill
2	S. K. Hajra Choudhury, A. K. Hajra Choudhury, Nirjhar Roy; Elements of Workshop Technology, Volumes I; Media Promoters & Publishers Pvt. Ltd.
3	P. H. Joshi; Jigs And Fixtures; TMH
RE FERENCES	
1	R. K. Rajput; Manufacturing Technology (Manufacturing Processes); Laxmi Publications (P) Ltd.
2	P.C. Sharma; A text book of Production Technology (Manufacturing Processes); S. Chand & Company Ltd.
3	E. Paul DeGarmo, J.T. Black, Ronald A. Kohser; Materials and processes in Manufacturing; Prentice Hall India.
4	R. K. Jain; Production Technology; Khanna Publishers

(Prof. Core 10) : DYNAMICS OF MACHINERY

Course Code	ME520		Credits	4	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	4	0	0	56 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO 1	Understand the basic principles of static and dynamics of rigid bodies, dynamometers, belt drives, balancing of rotating and reciprocating masses and mechanical vibrations

CO 2	Apply the principles of dynamics to estimate the forces in lower and higher order pair linkages, gyroscope, flywheel and governors and estimate undamped and damped natural frequency of vibration for single dof systems.
CO 3	Analyze linkages with lower and higher pair, gyroscopic effect, and vibratory response.
CO 4	Evaluate force and torque in linkages with lower and higher pair, gyroscopic couple, firing order of cylinder for balancing requirements.

UNIT-1	15 Hrs
Rigid Body Dynamics: Motion of Rigid body in Three Dimensions, Rigid Bodies in Spheric Motion, Principal Axes, Angular Velocity and Momentum about the Principal Axes, Euler's Equation of Motion. Gyroscopic Action in Machines: Gyroscopic Force and Couple, Effect of Gyroscopic Couple on an Aeroplane and Naval Ship, Stability of an Automobile and Motorcycle, Problems. Governor Mechanisms: Types of Governors, Centrifugal Governors – Watt, Porter, Proell, & Hartnell Governors, Characteristics of Centrifugal Governors, Hunting of Centrifugal Governors, Inertia Governors.	
UNIT-2	15 Hrs
Static Force Analysis: Static Force Analysis of Planar Mechanisms using the Method of Equilibrium, Method of Superposition, and Method of Virtual Work, Effect of Friction, Problems. Inertia Force Analysis: Inertia Force and inertia torque, D'Alembert'sPrinciple,Inertia Force Analysis of a Four Bar Mechanism, Inertia Force Analysis of a Reciprocating Engine Mechanisms, Dynamically Equivalent Systems, Engine Output Torque, Shaking Force and Shaking Couple, Problems. Flywheel: Turning Moment Diagram, Fluctuation of Crankshaft Speed, Flywheel in IC Engine, Flywheel in Punching Press	
UNIT-3	15 Hrs
Balancing of Rotating Masses: Internal and External Balancing, Static and Dynamic	
Balancing, Two Plane Balancing, Determination of Balancing Masses using Graphical and Analytical Methods, Balancing Machines, Problems. Balancing of Reciprocating Masses: Balancing of Reciprocating Engine Mechanism, Partial Balancing & its Effects (theoretical aspects), Firing Order, Balancing of MultiCylinder Inline Engines, V Engine, and W Engine, Opposed Engines, Method of Direct and Reverse Crank, Problems.	
UNIT -4	15 Hrs
Undamped Free Vibration of Single Degree of Freedom Systems: Introduction, Terminology, Basic Elements of Vibratory Systems, Degrees of Freedom, Natural Frequency, Differential Equation of Motion and its Solution for Single DOF Systems, using Equilibrium Method, Energy Method, and Rayleigh's Method, Equivalent Springs, Compound Pendulum, Bifilar, Trifilar Suspensions, Initial Value Problems. Damped Free Vibrations of Single Degree of Freedom Systems: Damping, Differential Equation of Motion and its Solution for Viscously Damped Free Vibrations of Single DOF Systems – Underdamped, Critically Damped, and Overdamped Cases, Damping Ratio, Logarithmic Decrement, Initial Value Problems. Introduction to Forced Vibrations.	

TEXTBOOKS	
1	S. S. Rattan; Theory of Machines and Mechanisms, Tata McGraw Hill; 2017
2	J. S. Rao, R. V. Dukkipati: Mechanism and Machine Theory; New age International; 1989
3	Ambekar; Mechanism and Machine Theory; Prentice Hall of India; 2007
4	G. K. Grover, Mechanical Vibrations, Nem Chand & Bros., 5e, 1993
RE FERENCES	
1	V. P. Singh, Mechanical Vibrations, Dhanpat Rai &Co., 5e, 2016
2	J. S. Mehta, A. S. Kailey, Mechnaical Vibrations, S. Chand Publication, 1e, 2012
3	J. E. Shigley, J. J. Uicker; Theory of Machines and Mechanisms; McGraw Hill; 2010
4	Ghosh, A. K. Malik; Theory of Mechanisms and Machines; East west Publishers; 3e.; 2006
5	Shames, G. K. M. Rao: Engineering Mechanics: Statics and Dynamics; Pearson Education; 2009
6	P. Beer, E. R. Eisenberg, E. R. Johnston, W. E. Clausen: Vector Mechanics for Engineers; Tata McGraw Hill, 10e; 2013
7	P. L. Ballaney; Theory of Machines and Mechanisms; Khanna Publication; 2001

Prof. Elect– 1(a):ADVANCEDTHERMODYNAMICS

Course Code	ME531		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

This course aims to provide a good platform to mechanical engineering students to understand, advanced concepts involved in thermal energy transformation.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the behavior of combustion of fuels, gas and vapour and different Thermodynamic cycles
CO 2	Apply the knowledge of mathematics, science and engineering fundamentals to study combustion phenomenon, Psychrometry and thermodynamic cycles.
CO 3	Analyze combustion equations, exhaust gases, Psychrometric Processes, Air and Vapour Cycles.
CO 4	Evaluate Combustion, properties of Gas and Vapour Mixtures and performance of different thermodynamic cycles.

UNIT-1	10 Hrs

FUELS AND COMBUSTION Classification of Fuels, Solid Fuels, Liquid Fuels, Gaseous Fuels, Basic Chemistry, Combustion Equations, Theoretical Air and Excess Air, Stoichiometric Air Fuel (A/F) Ratio, Air-Fuel Ratio from Analysis of Products, How to Convert Volumetric Analysis to Weight Analysis, How to Convert Weight Analysis to Volumetric Analysis, Weight of Carbon in Flue Gases, Weight of Flue Gases per kg of Fuel Burnt, Analysis of Exhaust and Flue Gas, Internal Energy and Enthalpy of Reaction, Enthalpy of Formation (ΔHf), Calorific or Heating Values of Fuels, Determination of Calorific or Heating Values, Solid and Liquid Fuels, Gaseous Fuels, Adiabatic Flame Temperature, Chemical Equilibrium, Actual Combustion Analysis	
UNIT-2	10 Hrs
GASES AND VAPOUR MIXTURES Introduction, Dalton's Law and Gibbs-Dalton Law, Analysis of a Gas Mixture, The Apparent Molecular Weight and Gas Constant, Specific Heats of a Gas Mixture, Mixing of Perfect Gases ,Gas and Vapour Mixtures. PSYCHROMETRICS Concept of Psychrometry and Psychrometrics, Definitions, Psychrometric Relations Psychrometers, Psychrometric Charts, Psychrometric Processes, Mixing of air streams, Sensible heating, Sensible cooling, Cooling and dehumidification, Cooling and humidification, Heating and dehumidification, Heating and humidification.	
UNIT-3	11 Hrs
GAS TURBINE CYCLE Ideal Brayton cycle, Pressure ratio for maximum work, Work ratio, Open cycle gas turbine-actual brayton cycle, Methods for improvement of thermal efficiency of open cycle gas turbine plant, Effect of operating variables on thermal efficiency, Closed cycle	
gas turbine, Gas turbine fuels. Derivation & calculations, JET AND ROCKET PROPULSION Theory, Classification of jet engines, Thermodynamic cycle - Ram-jet, turbo-jet, turbo prop, I and II law analysis on each cycle, thermal efficiency, Carnot efficiency and propulsive efficiency, Derivation & calculations, Basic rocket propulsion air cycle analysis.	
UNIT -4	11 Hrs
MODIFIED VAPOUR POWER CYCLE Regenerative Cycle, Reheat Cycle, Binary Vapour Cycle, Reheat-regenerative Cycle, Feed water Heaters, Energy Analysis of Vapour Power Cycles, Characteristics of an ideal working fluid in vapour power cycles, Binary Vapour Cycle. AIR AND VAPOUR REFRIGERATION CYCLE Introduction and Classification of Refrigeration systems, Reversed Carnot cycle, Reversed Brayton cycle, Merits and demerits of air refrigeration system, Simple vapour compression cycle, Vapour compression cycle on temperature-entropy (T-s) and Pressure-enthalpy (p-h) diagrams, Factors affecting the performance of a vapour compression system, Actual vapour compression cycle.	

TEXTBOOKS

1	Y. A. Cengel, M. A. Boles; Thermodynamics – An Engineering Approach; Tata McGraw Hill Education Pvt. Ltd. New Delhi.4th Ed; 2012.
2	P. K Nag; Engineering Thermodynamics; Tata McGraw Hill Education Pvt. Ltd.; New Delhi.4th Ed.; 2008.
RE FERENCES	
1	G. V. Wylen; R. Sonntag, C. Borgnakke; Fundamentals of Classical Thermodynamics; John Wiley & Sons, 4th Ed.; 1996.
2	J. B. Jones, R. E. Dungan; Engineering Thermodynamics; Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Ed.; 1996.
3	E. Radhakrishna; Fundamentals of Engineering Thermodynamics; Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Ed.; 2011.

PE 1(b): MECHANICAL VIBRATIONS

Course Code	ME532		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To understand the phenomenon of vibration.
2. To analyse single degree of freedom systems using different methods.
3. To formulate models and solve differential equations of motion.
4. To analyse free and forced vibration effects using classical and numerical methods

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand simple harmonic response in structures and machinery, undamped, damped free and forced vibrations for single and multiple degrees of freedom systems, critical speeds and vibration measurement.
CO 2	Apply the relations forundamped and damped free and forced vibrations for single and multiple degrees of freedom systems for estimating natural frequencies and mode shapes.
CO 3	Analyze system responses to steady state and transient excitation, critical speeds of shafts and use of vibration instrumentation for condition monitoring.

CO 4	Evaluate the Vibration parameters for systems subjected to free and forced vibrations using classical and numerical methods.

UNIT-1	11 Hrs
Introduction: Definitions & terminology. Elements of a vibrating system, Harmonic motion Undamped Free Vibration: Equations of motion using Newton's method, DAlembert's method, Energy method, Systems having angular oscillations, Equivalents springs, Bifilar &Trifilar suspension, Initial value problem Damped Free Vibrations of single degree of freedom system:Free vibration with viscous damping, overdamped, underdamped & critically damped systems, logarithmic decrement, Initial value problems,	
UNIT-2	11 Hrs
Forced Vibrations of single degree of freedom systems:Forced Vibration with constant harmonic excitation, Excitation by rotating & reciprocating unbalance, Harmonic motion of support, Vibration measuring instruments, Force & motion transmissibility, Vibration Isolation. Two degrees of freedom system: Free vibrations & the Eigen value problem, use of flexibility and influence coefficients, properties of vibrating systems, two rotor systems, and two rotors stretched on a tightly stretched string, double pendulum, and Vibration absorbers	
UNIT-3	10 Hrs
Transient Vibrations: Method of Laplace transformations, Responses to impulsive excitation, Responses to step & pulse input, Phase plane method, Duhamel's integral method. Multi degrees of freedom system: Rayleigh's method, Dunkerley's method, Holzers method, method of Matrix Iteration, Stodola'smethod	
UNIT -4	10 Hrs
Critical Speeds of shafts: Critical speed of a light shaft having a single disc without damping and with damping Experimental methods in Vibration Analysis: Vibrations exciters, Signal Analysis techniques Time domain, frequency domain & Cepstrum, Amplitude & Power Spectra, Auto and Cross correlations, Amplitude& frequency modulation, Fast Fourier Transform analyzer.	

TEXTBOOKS

1	J.S. Rao , K Gupta, theory & Practice of Mechanical Vibrations, New Age International, 2e, 1999
2	G. K. Grover, Mechanical Vibrations, New Chand & Bros; 8e; 2009
RE FERENCES	
1	S.S. Rao, Mechanical Vibrations, Pearson Inc.,4e 2004
2	V.P. Singh, Mechanical Vibrations, S.K Kataria& sons, 3e, 2006
3	W.T. Thomson, Mechanical Vibrations, Prentice Hall of India, 5e, 2007

Prof. Elec-1 (c) MECHATRONICS

Course Code	ME533		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To describe key elements of Mechatronics system and automation tools.
2. To introduce basic concepts of Control engineering.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic concepts and working principle of elements of mechatronic system
CO 2	Apply the concepts of various mechatronic sub system to build a simple mechatronic system
CO 3	Apply the concepts of Fluid power systems and PLC programming to develop simple automation systems
CO 4	Analyze mechatronic system using concepts of control engineering

UNIT-1	11 Hrs

Introduction to Mechatronics: Definition, open loop & closed loop control systems, Basic elements of closed loop control system, 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	11 Hrs
Sensors: Performance terminology of sensors, RTD sensor, Absolute Encoder, Capacitive & Inductive proximity sensor, LVDT, Load Cell, Photoelectric sensor, 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	
UNIT-3	10 Hrs
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, Working Principle of stepper and servo motor Data acquisition: Basics of PC based data acquisition.	
UNIT-4	10 Hrs
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 and micro actuator, basic concept of micro motor and micro optical components.	

TEXTBOOKS	
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
RE FERENCES	
1	A. Smaili, F. Mrad; Mechatronics: Integrated technologies for Intelligent Machines; Oxford University press; 2009
2	K. P. Ramachandran, G. K. Vijayaraghavan, M. S. Balasundaram; Mechatronics: Integrated Mechanical Electronic systems; Wiley India; 2015

3	D. G. Alciatore, M.B. Histand; Introduction to Mechatronics and Measurement Systems; Tata McGraw Hill; 2e; 2003
4	D. Shetty, R. A. Kolk; Mechatronics System Design; Cengage; 2e; 2012
5	T. C. Chang, R. Wysk, H. P.Wang; Computer Aided Manufacturing, Pearson; 3e; 2010
6	J. Prasad, M. N. Jayaswal, V. Priye; Instrumentation & Process Control, I. K. International Publishing House Pvt Ltd; 2012
7	T. Hsu; MEMS & Microsystem Design & Manufacture; Tata McGraw Hill; 2012
8	S. Soloman, Sensors and Control systems in Manufacturing; Mcfgraw Hill Professional publishing, 2e, 2009

Prof Elect. 1(d) MANAGEMENT INFORMATION SYSTEMS

Course Code	ME534		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO 1	Understand various concepts of MIS systems
CO 2	Apply tools /techniques/models/SQL in MIS
CO 3	Analyze various architecture/models/systems as applicable in MIS
CO 4	Evaluate the implementation of various entities in MIS

UNIT -1	10 Hrs

Fundamentals and Concepts: 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.	
UNIT -2	11 Hrs
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, Inventory control models. Enterprise Management Systems: Introduction, Enterprise Resource Planning (ERP) System. ERP basic features, Benefits of ERP, ERP implementation, EMS and MIS.	
UNIT -3	11 Hrs
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, 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	10 Hrs
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. Design and development phase, Implementation. Artificial Intelligence and Expert Systems in MIS: Introduction, AI - Definitions, Components of AI, Expert Systems - Introduction, Architecture, Goal of expert system, Working, Stages in expert system development, Advantages and limitations of expert system	

TEXTBOOKS	
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
R EFERENCES	
1	M. Gruber; Understanding SQL; John Wiley & Sons; 4e; 2000
2	E. Oz; Management Information Systems; Thomson Press (India) Ltd; 6e; 2013

3	D. P. Goyal; Management Information Systems: Managerial Perspective; Vikas Publishing; 2014

Prof Elect. 1(e) INDUSTRIAL SAFETY AND OCCUPATIONAL HEALTH					
Course Code	ME535		Credits	3	
Scheme of Instruction Hours/ Week	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125marks	IA	TW	TM	P	O
	25	0	100	0	0

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 Occupational Health.
4. To appreciate the ways of achieving Occupational Health.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the concepts related to industrial safety and occupational health.
CO 2	Apply techniques and methods for prevention of industrial accidents and occupational diseases.
CO 3	Analyze situations involving industrial accidents and occupational diseases.

CO 4	Evaluate situations involving industrial accidents, occupational diseases and develop solutions

UNIT-1	10 Hrs
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. Industrial Accidents: Definition of Accidents, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Nature, Causes, Classification. Accident costs, Measurement, Prevention. Investigation and analysis of accidents. Accident measurement. Accident Prevention: Method-Engineering, Education and Enforcement. Communication-purpose, Barrier to communication.	
UNIT-2	10 Hrs
Safety in Engineering Industry:Manual Material Handling, working on cranes, fork lift and machines. Planning for Safety: Planning procedure, Safety policy-Elements of safety policy,	
formulation and implementation of safety policy. Safety Education: Training, Accident Report and Insurance Coverage, Personal Safety, Welfare provisions and role of Factory Inspector. Safety Standards and Acts: Safety Standards, Factories Act	
UNIT-3	11 Hrs
Industrial Hazards and Prevention: Types of industrial hazards- Mechanical hazards and Machine safeguarding, Chemical Hazards, Fire hazard, prevention of fire, Fire detection and control, Extinguishers, Electrical hazards and safety requirements, Pressure vessel hazards, Safety precautions in boilers, Noise and noise control, Dust control. Hazard Identification Techniques:Failure mode and effect analysis (FMEA) technique, Hazard and operability review 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 -4	11 Hrs
Occupational Health: Concept and Significance of Industrial Health, Occupational safety and Health Administration, Occupational safety and Health Act. Occupational and Work Related Diseases: Types of Occupational diseases, Industrial toxicology, dangerous properties of chemicals and their health effects, routes of entry of toxic material into human body, permissible exposure limits, Threshold limit value, lethal dose and lethal concentration. Ergonomics: Musculoskeletal Disorders, application of Ergonomics for safety & health. Epidemiology and Biostatistics in Occupational Health: Concept, importance, Record Keeping.	

TEXTBOOKS	
1	L. M. Deshmukh; Industrial Safety Management; McGraw Hill Education (India) Pvt.Ltd. 2013
2	S. Z. Mansdorf; Complete Manual of Industrial Safety; Prentice Hall; 1993
3	K. T. Kulkarni; Introduction to Industrial safety; K. T. Kulkarni Publishers; 2002
RE FERENCES	
1	R. W. King, J. Magid; Industrial hazard And Safety Handbook; Butterworths; 1980
2	S. K. Haldar, Industrial and Occupational Health, CBS Publishers & Distributors, 1e, 2017
3	Basudev Panda, Industrial Safety, Health Environment and Security, Laxmi Publications, 1e, 2018
4	David Goetsch, Occupational Safety and Health, Pearson publication, 9e, 2019

(Prof. Elect. – 2 (a)) GAS DYNAMICS AND TURBOMACHINERIES

Course Code	ME 541		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To introduce the fundamental concepts of compressible flow.
2. To understand conceptually jet propulsion.
3. To understand the fundamental concepts of turbo machinery.
4. To understand the fundamental concepts of Hydraulic turbine, Centrifugal Pump

Course Outcomes:

On completing this course students will be able to:

CO 1	Remember concept of compressible flow. Understands working of power absorbing and generating turbomachinaries.
CO 2	Understand shock wave phenomenon. Understand energy exchange in Turbomachineries
CO 3	Analyze change in properties across shock wave and manometric head and minimum speed of centrifugal pumps.
CO 4	Evaluate compressible flow through ducts with area variation, heat transfer and friction, analyze power generating and absorbing Turbomachineries using velocity triangle.

UNIT-1	11 Hrs

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 no relations, Impulse function, effects of different pressure ratios across a supersonic nozzle, under expansion & over expansion, mass flow rate in nozzles.	
UNIT-2	10 Hrs
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. FLOW WITH HEAT TRANSFER AND FRICTION: Hugoniot equation, Prandtl-Mayer equation, Hugoniot curve, Fano and Rayleigh flows and curves.	
UNIT-3	10 Hrs
INTRODUCTION TO TURBOMACHINES: Definition & 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: Degree of Reaction, Reheat factor and Turbine utilization factor. Enthalpy Entropy diagrams for power generating and power absorbing turbomachines.	
UNIT -4	11 Hrs
HYDRAULIC TURBINES: Introduction & classification of turbines, selection based on specific speed. Construction, work done & efficiencies, of Pelton wheel, Francis and Kaplan turbines, numericals. CENTRIFUGAL PUMPS: Construction & classification, Types of heads & efficiencies, Velocity triangles and analysis - effect of blade outlet angle on energy transfer, Characteristic curves, Minimum speed, NPSH and cavitation, Series & parallel arrangement.	

TEXTBOOKS	
1	Fundamentals of Compressible Flow- P. Balachandran, Prentice Hill of India.
2	Turbomachines- B.U. Pai (Wiley India).
3	Fluid mechanics & Hydraulic Machines - R.K.Rajput, S. Chand & Co.
4	Fundamentals of Turbomachineries- B.K.Venkanna Prentice Hill of India.
5	Gas Turbines, V. Ganesan. Tata McGraw Hill Publishers
RE FERENCES	
1	An Introduction to Energy Conversion: Turbomachinery, V. Kadambi, Manohar Prasad, New Age Publishers

2	Fundamentals of Compressible Flow- S.M.Yahya, New Age International Publishers.
3	Gas Dynamics and Jet Propulsions-Somasundaram. PR.S.L, New Age International Publishers.
4	Fundamentals of Gas Dynamics, Babu. V., ANE Books India.
5	Gas Turbine Theory- Cohen. H., G.E.C. Rogers and Saravanamutto, Longman Group Ltd.
6	Gas Dynamics, EthirajanRadhakrishanan, PHI.
7	Modern Compressible Flow- Anderson, Tata Mc Graw Hill

Prof Elect. 2 (b) ENGINEERING TRIBOLOG Y

Course Code	ME542		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To introduce the fundamental principles of friction, wear & fluid film lubrication.
2. To study & analyse the different bearings used in engineering applications.
3. To develop the ability to select / design bearings for engineering applications

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the principles of friction & wear mechanisms, fluid film lubrication, hydrostatic, hydrodynamic and elasto – hydrodynamic lubrication
CO 2	Apply theories of fluid film lubrication in relation to hydrostatic, hydrodynamic and elasto – hydrodynamic lubrication and the knowledge of bearing materials and application of science of tribology.
CO 3	Analyse & calculate bearings parameters for hydrostatic, hydrodynamic and elasto – hydrodynamic lubrication
CO 4	Evaluate bearings parameters for hydrostatic, hydrodynamic and elasto – hydrodynamic lubrication

UNIT-1	10 Hrs

Introduction: Meaning of Tribology, friction, wear & lubrication. Friction: Laws of Friction,Physical basis of Laws of Friction, Adhesion, Junction Growth, Static & kinetic friction, stick - slip phenomenon, measurement of friction Wear: Definition & its classification, Archard's Wear Equation, Wear Maps, Wear Mechanism – Seizure, Melt Wear, Oxidation Wear, Mechanical Wear - Running – in Wear, adhesive wear, erosive wear, cavitation, corrosive wear, fatigue wear, fretting wear.	
UNIT-2	10 Hrs
Lubrication and its physical properties: Requisite properties of lubricants, Oil viscosity & viscosity Index, Oil viscosity Classification, Viscosity relationship with temperature, Pressure & Shear Rate, Viscosity Measurement – Capillary & Rotational. Regimes of Fluid Film Lubrication: Hydrostatic, Hydrodynamic, Elasto hydro Dynamic, Mixed & Boundary Lubrication Hydro – static Bearings: Analysis of Flat circular hydrostatic pad bearings for Pressure distribution, Lubricant flow, Load capacity, Frictional torque & power loss, Control of stiffness through capillary restrictors & orifice.	
UNIT-3	11 Hrs
Hydrodynamic Lubrication:	
Towers Experiment, Reynolds Equation – Assumptions & RE in 3 – D, simplification Pad Bearings: Infinite Linear pad bearing: Bearing geometry, pressure distribution, load capacity, frictional force, Coefficient of friction, lubricant flow rate. Journal Bearings: Narrow Bearing: Bearing geometry, pressure distribution, load capacity, frictional force, Coefficient of friction, lubricant flow rate. Idealized Journal Bearing: Pressure distribution, load capacity	
UNIT -4	11 Hrs
Elasto Hydrodynamic Bearings: Contact Stress, contact parameters between elastic bodies with varied geometry – Contact area, pressure, maximum deflection and position of maximum shear stress, Effects contributing to generation of Elasto - hydrodynamic films, Grubin's expression for film thickness in EH linear contact. Application of Tribology: Rolling Contact Bearings, Gears &tribo testing. Bearing material: General Requirements of Bearing Materials, Type of Bearing Materials.	

TEXTBOOKS	
1	GwidonStachowiak Andrew Batchelor, Engineering Tribology, Butterworth Heinemann, Elsevier Inc, 2014

2	B.C. Majumdar, Introduction to Tribology of Bearings, S. Chand & Co., 2015
RE FERENCES	
1	Bharat Bhushan, Introduction to Tribology, Wiley Publication, 2013
2	S. K. Srivastava, Tribology in Industries, S. Chand & Co., 2012

Prof Elect – 2(b) ADVANCED MACHINE DESIGN

Course Code	ME543		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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 machine Element Design

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic principles of designing clutches, brakes, flywheel gears, I. C. Engine components, power screws, Sliding contact bearings and selection of R. C. bearings.
CO 2	Comprehend and apply mathematical relations for designing clutches, brakes, flywheel gears, I. C. Engine components, power screws and Sliding contact bearings.
CO 3	Analyze the problems related to design of clutches, brakes, flywheel gears, I. C. Engine components, power screws and sliding contact bearings and R. C. Bearings
CO 4	Evaluate the dimensions of the above machine elements for loading conditions specified and select appropriate R. C. bearings for given applications using standard data books / manufacturer's catalogue.

UNIT-1	11 Hrs

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. Issue of heating of brakes. Flywheel: Objectives of flywheel, comparison with governor, torque analysis, coefficient of fluctuation of speed and coefficient of fluctuation of energy, stress analysis in solid disc flywheel and rimmed flywheel. Designing of flywheel for I.C. Engines and Punch Press applications.	
UNIT-2	11 Hrs
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 L10 life, RC bearings subjected to cyclic loads and speeds, Mounting of bearings	
UNIT-3	10 Hrs
Gears: Classification of gears, selection of Gears, Law of Gearing. Introduction to design of involute spur gears. 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 Hrs
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. Application of Power Screw principles to design Screw Jack and Turnbuckle. Patent and Intellectual Property: Introduction to Intellectual Property, types of Intellectual Property.	

TEXTBOOKS	
1	V. B. Bhandari Design of Machine Elements; Tata McGraw
2	J. E. Shigley; Mechanical engineering Design; Metric Edition; McGraw
RE FERENCES	
1	A.S Hall., A.R. Holowenko and H.G Laughlin; Theory and Problems of Machine Design; Schaum's Outline Series; 1981.
2	C.S.Sharma and K. Purohit; Design of Machine Elements; PHI Learning Pvt. Ltd; 2009.

3	D. K. Aggarwal & P. C. Sharma; Machine Design; S.KKataria and Sons; 2013
4	PSG College Coimbatore - KalaikathirAchchagam; Design Data Book; 2012.
5	K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, 4e, CBS Publishers; 2015.
6	M. F. Spotts, T.E.Shoup; Design of Machine Elements, Prentice Hall International; 1998

Note: Only Reference Books at No. 4 and 5 to be used as data books in semester examination. These reference books (Data Books) at 6 and 7 above are to be provided by the College Examination Cell. Students should not be allowed to carry their own data books in the examination hall

Prof. Elec-2 (c) MICROELECTROMECHANICAL SYSTEMS (MEMS)

Course Code	ME544		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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, actuators, integration and packing of micro systems.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basics of MEMS systems and their micro fabrication techniques
CO 2	Select appropriate sensors and actuators for a given MEMS application
CO 3	Select a micro-fabrication technique for a specific MEMS fabrication process
CO 4	Apply the concepts of basic science in design and modeling of MEMS systems

UNIT-1	11 Hrs
Introduction to Micro and Smart Systems: Smart materials, Structures and systems, Components of a smart system, Microsystems, Micromachined transducers, Applications of MEMS. Micro Sensors and Actuators :Working principle of Microsystems , micro sensors type:Silicon capacitive accelerometer, Piezo-resistive pressure sensor, Biosensors, Microactuator types: micropump, micromotors, micro valves, microgrippers, microaccelerometers	
UNIT-2	11 Hrs

Fabrication Methods: Bulk and Surface Micromachining, Etching (Isotropic and Anisotropic), Deposition techniques: Chemical Vapor Deposition, Metallization Techniques, 3D High Aspect Ratio Techniques: LIGA, Ion-beam Lithography. 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	10 Hrs
Modeling: Scaling issues, Elastic deformation and stress analysis of beams and plates, Thermal loading, Heat transfer issues, Basic fluid issues, Electrostatics. Coupled electromechanics. Electromagnetic actuation, Capillary electro-phoresis, Piezoresistive modelling, Piezoelectric modelling, Magnetostrictive actuators .	
UNIT-4	10 Hrs
Integration and Packaging of Micro electro Mechanical Systems: Integration of microdevices 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: BEL pressure sensor and active vibration control.	

TEXTBOOKS	
1	MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering By Tai-Ran Hsu, 2nd edition
2	Microsystem Design, S.D. Senturia, 2001, Kluwer Academic Publishers, Boston. USA.ISBN 07923-7246-8.
3	Analysis and Design Principles of MEMS Devices, Minhang Bao, Elsevier, Amsterdam, theNetherlands, ISBN 0-444-51616-6, 1st edition
4	Design and Development Methodologies, Smart Material System and MEMS: V Varadan, K.J.Vinoy, S. Gopalkrishnan, Wiley., September 2006
RE FERENCES	
1	Fundamentals of mocro fabrication, the science of miniaturization –Max J. Madou, Nanogen corporation, USA, CRC press, March 2002
2	Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim ―Microsensors MEMS and Smart devices‖, John Wiley and sons, Ltd., November 2001
3	NadimMulaf and Kirt Williams, ―An Introduction to Microelectromechanical systems Engineering‖, Artech House., 2nd Edition
4	NicolaeLobontiu and Ephrahim Garcia, ―Mechanics of Microelectromechanical systems‖, Kluwer Academic Publication.2005 edition
5	Stanley Wolf and Richard Tauber, ―Silicon Processing for the VLSI era Volume -1 Technology‖, Lattice press

Prof. Elect 2 (e) INSTRUMENTATION AND CONTROL					
Course Code	ME545		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
2. To impart knowledge of mathematical modeling, characteristics and performance of control system.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand basic working principles of different measurement tools and control engineering concepts used in process industries
CO 2	Select temperature, flow, pressure and level measuring device for specific process
CO 3	Generate mathematical models of sensors and dynamic control systems
CO 4	Analyze the behavior of a control system in terms of different system and performance parameters

UNIT -1	11 Hrs
Instrumentation Systems: The Constituent Elements of an Instrumentation System, Difference between Instrument and Sensor, Static Characteristics of sensors, Reliability, Calibration, Safety. Temperature measurement: Introduction to temperature measurements, Techniques and Classification, Thermocouple, Thermistor, Radiation Thermometry- Total Radiation Pyrometer, Optical Pyrometer. Pressure measurement: Introduction, Basic principle of Manometer, Elastic Type: Bourdan tube, Diaphragm type, Electrical Type, Low pressure (Vacuum) measurement, Piezoelectric sensor, Differential Pressure Transmitters, I/P and P/I Converters. Displacement & speed measurement: Potentiometer, Mechanical Switches, Tachogenerator	
UNIT -2	10 Hrs

Distance measurement & Range sensors: Ultrasonic Sensor, Infra-red Sensor, Microwave Sensors Level measurement: Introduction, Float Type, Displacer Type, Hydrostatic, Differential pressure level detector, Capacitance level sensor, Ultrasonic level detector and Radar level transmitter, Nucleonic level indicator Flow measurement: Introduction and classification of flow meters, Differential Pressure (Head Type): Variable area flow-meters & Positive displacement flow meters, Electro Flow meters: Turbo-magnetic & Electromagnetic. Case studies : Smart Actuators- The Future of Automobile Systems, Heart Beat Sensor and Automobile Tyre Pressure Monitoring	
UNIT -3	11 Hrs
Introduction and Modeling of control system: Review of Systems Models (Mechanical & Electrical), Mathematical Models – Differential Equations, Transfer Functions, Block Diagrams, Feedback Control System. System Response: Transients and steady-state response for First and Second Order System, its Characteristics and Performance Specifications, Dynamic response of sensors.	
UNIT -4	10 Hrs
The Root Locus Method: Introduction, Significance of root loci. Construction of loci, general procedure. Loci equations of parameters Compensators: Lead, Lag, Lag-Lead, Parallel Compensators Controllers: P, I, D and PID Controllers. Controller Tuning	

TEXTBOOKS	
1	Ernest.O.Doebelin and Dhanesh.N.Manik, Doebelin‘s Measurement Systems, McGraw Hill Education, 6th Edition, 2011
2	Patranabis D, Principles of Industrial Instrumentation, Tata McGraw Hill, 3rd Edition, 2010.
3	Katsuhiko Ogata, ―Modern Control Engineering‖, PHI Learning Private Ltd, 5th Edition, 2010
	Nise, N.S., Control Systems Engineering, Wiley, 7th Edition, 2015
R EFERENCES	
1	B. C. Kuo; Automatic Control Systems; Wiley; 9e; 2014
2	J. Nagarath, M.Gopal; Control Systems Engineering, New Age International (P) Limited; 6e; Jan 2017
3	Douglas M. Considine, Process / Industrial Instruments & Controls Handbook, McGraw Hill, Singapore, 5th Edition, 1999
4	William Bolton, Instrumentation and Control, Elsevier, 2nd Edition, 2015
5	S. Graham Kelly, System Dynamics, CENGAGE Learning, India Edition, 2003
6	1. W. Bolton; Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering; Pearson; 3e; 2005

7	S. K. Singh; Industrial Instrumentation and Control, Tata McGraw-Hill Education, 2003
8	S. Soloman, Sensors and Control systems in Manufacturing; Mcfgraw Hill Professional publishing, 2e, 2009

MANUFACTURING LABORATORY					
Course Code	ME570		Credits	2	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	28 hrs/sem	
Scheme of Examination TOTAL =75 marks	IA	TW	TM	P	O
	0	25		50	0

Course Objectives:

1. To practically demonstrate casting, forming and welding processes.
2. To inculcate safe practices during the fabrication and joining process.

Course Outcomes:

On completing this course students will be able to

1. Apply the concepts of Casting and Forming for the fabrication of simple components.
2. Apply the concepts of welding for making simple joints.

LIST OF EXPERIMENTS	
PART A Welding 1. Create a butt joint in various positions using welding. 2. Create a lap joint in various positions using welding. PART B Foundry Practice 1. One job of casting using sand molding. PART C Forging & Sheet metal Operations 1. One job on forging. 2. One job on sheet metal.	

DYNAMICS OF MACHINERY LABORATORY					
Course Code	ME580		Credits	1	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	28 hrs/sem	
Scheme of Examination TOTAL =100 marks	IA	TW	TM	P	O
	0	25	0	50	0

Course Objectives:

1. To provide an insight into static and dynamic force analysis and working of governor
2. To provide training to students to enhance their practical skills.
3. To practically demonstrate Gyroscopic rule and balancing of rotating mass. 4. To determine natural frequency of single degree freedom system
5. To develop team qualities and ethical principles.

Course Outcomes:

On completing this course students will be able to:

1. Understating the principles ofnatural frequency, gyroscopic rule and characteristics of governor.
2. Apply static and dynamic force analysis on linkages.
3. Interpret the results and draw appropriate conclusions.

LIST OF EXPERIMENTS	
1. Static and dynamic balancing of rotating masses. 2. Characteristics of dead weight controlled governor 3. Characteristics of speed controlled governor 4. Verification of gyroscopic rule 5. At least two sheets on force analysis of mechanisms (static and dynamic) 6. At least two sheets on balancing 7. Determination of natural frequency of single dof systems 8. Determination of mass M. I. using compound pendulum / Bifilar / Trifilar suspension	

ENGINEERING STATISTICS					
Course Code	HM010		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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 and regression

Course Outcomes:

On completing this course students will be able to:

CO1	Understand the concepts of randomness, probability distributions, inferential statistics and linear regression
CO2	Explain the development of characteristics of random variable, standard probability distributions and sampling distributions, applications of inferential statistics and linear regression
CO3	Compute - Probabilities and characteristics associated with random variable, outcomes in inferential statistics and coefficients of linear regression
CO4	Evaluate - behaviour of randomness, Point and Confidence Interval Estimators, Test of Hypothesis and regression model

UNIT 1	
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, MomentGenerating function. Function of One Dimensional Random Variable: Discrete and continuous case, E and V-operations with approximations	10 Hours
UNIT 2	

Discrete Probability distributions: Bernoulli trial, Binomial, Geometric, Poisson distribution. Mean, Variance, Distribution functionand Moment Generating Function. Important properties, approximations, applications and numericals. No derivations.Continuous Probability distributions: Uniform, Exponential and	12 Hours
Normal distribution. Mean, Variance Distribution functionand Moment Generating Function, important properties, approximations, applications, and numericals. No derivations	
UNIT 3	
Statistic and Sampling Distributions: Population and the Sample, Statistic, Sampling distributions- Normal, Student's t-distribution, Chi-square and F- distributions. Applications, numericals. No derivations. Parameter Estimation:Point Estimation-Definition, unbiased estimator, standard error, method of maximum likelihood. 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	10 Hours
UNIT 4	
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. Goodness of Fit Test:Chi-square test- Introduction, concept, algorithm for testing discrete and continuous distributions discussed in Unit 2, P-value. Test for Independence. Simple Linear Regression: Simple Linear Regression Concept, development of regression model, residual-computation and plotting	10 Hours

TEXTBOOKS	
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
RE FERENCES	
1	R. A. Johnson, Probability and Statistics for Engineers, 8e, Prentice Hall of India, 2011.
2	T. Veerarajan; Probability, Statistics and Random Processes, 3e, Tata McGraw Hill India; 2017

3	A. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015
4	J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010

SEMESTER VI

(Prof. Core – 11) HEAT AND MASS TRANSFER

Course Code	ME610		Credits	4	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	4	0	0	56 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To understand basic of the phenomena of heat transfer.
2. To develop methodologies for solving a wide variety of heat and mass transfer problems.
3. To understand heat Transfer rates and the consequent temperature distributions in different practical contexts.
4. To understand Mass transfer concepts.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic laws of heat transfer.
CO 2	Analyze problems involving steady state heat conduction in simple geometries.
CO 3	Apply the fundamentals of convective heat transfer process.
CO 4	Evaluate heat exchanger performance by using the method of log mean temperature difference.

UNIT-1	14 Hrs
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 & composite cylinders, Thermal contact resistance, Critical radius of Insulation: spheres & cylinders, Variable thermal conductivity, Thermal Insulation. CONDUCTION WITH HEAT GENERATION: Plane wall with uniform heat generation, Cylinder with uniform heat generation.	
UNIT-2	14 Hrs

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, 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	14 Hrs
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, Flow across Cylinders – the Drag coefficient, the heat transfer coefficient , Flow in tubes. NATURAL CONVECTION: Physical Mechanism of Natural Convection Empirical correlations. Natural Convection over surfaces –Natural Convection inside enclosures – effective thermal conductivity, Natural convection from finned surfaces. Introduction to boiling and condensation, Pool boiling regimes. Numericals.	
UNIT -4	14 Hrs
RADIATION HEAT TRANSFER: Thermal Radiation, Blackbody radiation , Radiation properties, Planck's law, Stefan Boltzman's Law, Wien's Displacement Law, Kirchhoff'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, 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. The mass transfer coefficient, isothermal evaporation process in the atmosphere, Convective mass transfer and Correlations for mass transfer.	

TEXTBOOKS	
1	Heat & Mass Transfer, R.K. Rajput, S. Chand & Co.
2	Heat and Mass Transfer, Dr. D. S. Kumar, S. K. Kataria& sons.
3	Heat transfer – A Practical Approach, Yunus A. Cengel, McGraw Hill.
RE FERENCES	
1	Heat transfer-A basic approach, Ozisik N.M, McGraw-Hill.
2	Heat Transfer, Taine & Petit, Prentice Hall.
3	Heat Transfer, Holman J.P, McGraw-Hill

Prof. Core-12 Manufacturing Technology II					
Course Code	ME620		Credits	4	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	4	0	0	56 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

This course will enable students to:

1. Impart the fundamental knowledge of metal cutting.
2. Introduce the concepts of non conventional manufacturing and finishing processes

.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the working principle of conventional &non conventional manufacturing processes
CO 2	Understand the working principle of various finishing processes
CO 3	Apply the concepts of cutting tool life and tool wear for conventional machining processes
CO 4	Select the appropriate manufacturing process for a given product

UNIT-1	14 Hrs
Theory of Metal Cutting: Single point cutting tool nomenclature. Mechanics of Chip Formation, Types of Chips. Merchants circle diagram and analysis, modified merchant theory, shear angle relationship, problems on Merchant‘s analysis. Tool Wear and Tool failure: Effects of cutting parameters on tool life. Tool Failure Criteria, Taylor‘s Tool Life equation. Problems on tool life equation. Cutting Tool Materials: Desired properties and types of cutting tool materials – High carbon steel, HSS, carbides, coated carbides, ceramics (Composition and selection). Cutting fluids: Desired properties, types and selection.	
UNIT-2	14 Hrs

Turning (Lathe), Shaping and Planning Machines: Classification, constructional features of Turret and Capstan Lathe. Construction and working of Shaping Machine, Planning Machine, Different operations on shaping machine and planning machine. Simple problems on machining time calculations Drilling machines: Classification, constructional features, drilling & related operations. Types of drill & drill bit nomenclature, drill materials. Sheet Metal working: Standard die set and its accessories. Press working operation: Blanking, Shearing, Punching, Piercing, Notching, Slotting, Trimming, Bending, Drawing, Embossing, Calculation of free length of blank.	
UNIT-3	14 Hrs
Milling: Machine Classification, constructional features, milling cutters nomenclature, up milling and down milling concepts. Indexing: Simple, compound, differential and angular indexing calculations. Problems on simple and compound indexing. Grinding machines: Types of abrasives, Grain size grade and structure of grinding wheels, grinding wheel types. Classification, constructional features of Centerless, cylindrical and surface grinding machines. Selection of grinding wheel. Grinding process parameters.	
UNIT -4	14 Hrs
Finishing Processes: Lapping and honing operations – Principles and application. Super finishing process, polishing, buffing operation and application. Non-traditional machining processes Need for nontraditional machining, Principle, equipment & operation of Laser Beam, Plasma Arc Machining, Electro Chemical Machining, Ultrasonic Machining, Abrasive water Jet Machining, Electron Beam Machining, Electron Discharge Machining and Plasma Arc Machining.	

TEXTBOOKS	
1	Workshop Technology, Hazara Choudhry, Vol-II, Media Promoters & Publishers Pvt. Ltd. 2004
2	Production Technology, R.K.Jain, Khanna Publications, 2003
3	Production Technology, HMT, Tata Mc Graw Hill, 2001
RE FERENCES	
1	Manufacturing Science, Amitabha Ghosh and Mallik, affiliated East West Press, 2003
2	Fundamentals of Metal Machining and Machine Tools, G. Boothroyd, McGraw Hill, 2000

Prof. Elect. – 3 (a)POWER PLANT ENGINEERING					
Course Code	ME631		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To develop an ability to identify, formulate, and solve engineering problems.
2. To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes:

On completing this course students will be able to:

CO 1	Remember basics of Power Generation, solar, wind, tidal, Geothermal, Ocean, bio and new energy sources of power generation
CO 2	Understand working principles the various renewable energy sources like wind, solar, biomass, Ocean energy, Fuel cells and MHD systems.
CO 3	Apply principles of thermodynamics and energy conversion in different power plants
CO 4	Analyze performance of various Power Plants

UNIT-1	10 Hrs
Power Generation: Global Scenario, Present status of power generation in India, Role of private and governmental organizations, 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, load curve and load duration curves and terminology. Cost of generation of electrical energy with numerical, Selection and Type of generation, Selection of generating equipment and electrical energy Tariff methods.	
UNIT-2	11 Hrs

Steam Power Plants: 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, cogeneration power plant, Necessity of steam condenser, Classification, cooling water requirements, Condenser efficiency, Vacuum efficiency, Cooling towers, air Leakage, Effects of Air Leakage on condenser performance. Diesel Power Plants: Plant Layout, Diesel Engine Power Plant Performance Analysis, application, selection of engine size, advantages & disadvantages of diesel power plant.	
UNIT-3	11 Hrs
Nuclear Power Plants: 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 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.	
UNIT -4	10 Hrs
Non-Conventional Power Plants: Introduction, Solar Power Thermal Plants. Solar Photovoltaic Power System, Wind Power Plant, Tidal, Ocean Thermal Energy Conversion (OTEC), geothermal, magneto hydrodynamics, fuel cell, Thermoelectric, Thermionic Generarots, Nuclear Batteries, 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 & greenhouse effect, thermal pollution of water & its control. Noise pollution by power plants.	

TEXTBOOKS	
1	E.I.Wakil, ―Power Plant Engineering‖, McGraw Hill Publications New Delhi
2	P.K.Nag, ―Power Plant Engineering‖, McGraw Hill Publications New Delhi
3	K KRamalingam ,‖ Power Plant Engineering, SCITECH Publications Pvt Ltd
RE FERENCES	
1	Domkundwar& Arora, ―Power Plant Engineering‖, Dhanpat Rai & Sons, New Delhi
2	R.K.Rajput, ―Power Plant Engineering‖, Laxmi Publications New Delhi
3	R.Yadav , ―Steam and Gas Turbines‖ ,Central Publishing House, Allahabad
4	D .K.Chavan&G.K.Phatak, ―Power Plant Engineering‖ , Standard Book House, New Delhi.

5	S.P.Sukhatme, ―Solar Energy‖ Tata McGraw-Hill Publications, New Delhi

Prof Elect. 3 (b) ADVANCED MECHANICS OF SOLIDS					
Course Code	ME632		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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 Outcome:

After undergoing this course, students will be able to:

CO 1	Understand the principles of asymmetric bending, curved beam theory, three dimensional stresses, strain, theory of elasticity, axis-symmetric problems and energy methods in evaluating structures.
CO 2	Apply the relations of un-symmetric bending, curved beam theory, theory of elasticity, axis-symmetric problems and energy methods in engineering problems.
CO 3	Analyze the structural members for stresses, strains and displacements subjected to external loading.
CO 4	Evaluate the stresses, strains and displacements in members subjected to external loading including axis symmetric members and curved members and use of energy methods to evaluate structures.

UNIT-1	12 Hrs

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 Hrs
Theory of elasticity: Constitutive equations, equations of elasticity, uniqueness theorem, principle of superposition, Saint Venant's principle, Airy's stress function. Twodimensional 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 Hrs
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 Hrs
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	

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

Prof.l Elective – 3 (c) FIBER REINFORCED COMPOSITES					
Course Code	ME633		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To acquire comprehensive understanding of processing various composites using different processing methods, to get an overview of the principles involved in the mechanics of FRCs
2. To be able to apply the elementary theories to various problems involving FRCs, understand theories of failure to FRCs under load.

Course Outcomes:

On completing this course students will be able to:

CO 1	Explain the constituent materials, manufacturing mehods, fibre-matrix interactions and recycling of fibre reinforced composites
CO 2	Determine stresses during longitudinal & transverse loading of unidirectional continuous & discontinuous fibres reinforced composites
CO 3	Evaluate the compliance and stiffness matrices in unidirectional continuous fibres reinforced composites
CO 4	Apply the quality inspection & mechanical testing methods and predict failure in fibre reinforced composites

UNIT-1	11 Hrs
Introduction to Fibre Reinforced Composites: Definition, General characteristics, Classification, Advantages, Disadvantages and Applications of fibre reinforced composites FibreMaterials:Naturalfibres,Glass fibres, Carbon Fibres, Aramid Fibres, Boron fibres, Ceramic Fibres and their manufacturing, 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 Incorporation of fibres into matrix – Prepregs and Sheet Moulding Compounds (SMC)	
UNIT-2	10 Hrs

FRC Manufacturing: Fundamental concepts: Degree of Cure, Viscosity, Resin Flow, Consolidation, Gel-time Test, Shrinkage, Voids Typical Manufacturing Processes: Hand Lay-Up Process, Spray-Up Process, Autoclave Moulding, Resin Transfer Moulding, Reaction Injection Moulding, Filament Winding, Pultrusion, Compression Moulding; Manufacturing Processes for Thermoplastic Matrix Composites (No Numericals).	
UNIT-3	11 Hrs
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 reinforced Composites. 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	
UNIT -4	10 Hrs
Elastic Properties of a Lamina: Stress–Strain Relationships for a Thin Lamina, Compliance and Stiffness Matrices (Derivations and Numericals) 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	

TEXTBOOKS	
1	P. K. Mallick, Fiber Reinforced Composites, CRC Press, 3rd Edition, 2007
2	Bhagwan D. Agarwal, Lawrence J. Broutman and K. Chandrashekhara, Analysis and Performance of Fiber Composites, 3rd Edition, Wiley India, 2012
3	Isaac M. Daniel and Ori Ishai, Engineering Mechancis of Composite Materials, 2nd Edition, Oxford University Press, 2013
RE FERENCES	
1	GuneriAkovali,Handbook of Composite Fabrication, Rapra Technology Ltd, 2001
2	M. Balasubramanian, Composite materials and processing, CRC Press, 2014
3	Sanjay K. Mazumdar, Composites Manufacturing - Materials, Product, and Process Engineering, CRC Press, 2002

Prof. Elec-3 (d1) QUALITY AND RELIABILITY					
Course Code	ME634		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO 1	Understand the concepts of quality, statistical process control, acceptance sampling, reliability engineering and reliability-based design.
CO 2	Apply the knowledge gained from statistical process control, acceptance sampling, reliability engineering and reliability-based design on different cases.
CO 3	Analyze using control charts, sampling plans, reliability measures and reliabilitybased design.
CO 4	Evaluate the performance using control charts, sampling plans, product/system reliability and reliability-based design.

UNIT-1	10 Hrs
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, Total Quality Management. 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, 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	10 Hrs

Control Charts for Attributes: Introduction, Control charts for non-conforming items (pchart, np-chart)- 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 nonconformities (c-chart, u-chart)- 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 concept; 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; Sequential Sampling Plan- design and application.	
UNIT-3	11 Hrs
Reliability Engineering: Need for Reliability, definition of reliability and its various measures, reliability analysis- Exponential, Normal, Lognormal and Weibull distribution. Derivation restricted only to only reliability and hazard function, Reliability of Systems - Series, Parallel and Combined Series-Parallel systems, Complex systems. Reliability Allocation - Equal Apportionment technique, ARINC Apportionment technique, AGREE Allocation method	
UNIT -4	11 Hrs
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 both Exponential, both Normal, both Lognormal. Reliability-based Design of Mechanical Components: Shaft (Tension and Torsion)	

TEXTBOOKS	
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.
RE FERENCES	
1	S. S. Rao; Reliability Engineering, Pearson Education; 2016
2	A. Mitra; Fundamentals of Quality Control and Improvement; Third Edition; Wiley India; 2008.
3	E. L. Grant, R. S. Leavenworth; Statistical Quality Control; Seventh Edition; McGraw Hill India; 2000
4	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.

Prof. Elec-3 (d2) APPLIED OPERATIONS RESEARCH					
Course Code	ME635		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	25

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:

On completing this course students will be able to:

CO1	Understand the applied concept of real life models, problem formulations and tools to solve various linear programming models
CO2	Apply the appropriate technique to solve any given real-life linear programming model
CO3	Analyze the formulation strategies of linear programming models and the complexity of solution procedures to solve linear programming problems
CO4	Evaluate the performance of various solution techniques used to solve the linear programming problems

UNIT 1	

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.	12 Hours
UNIT 2	
Transportation model: Introduction, Formulation, Transportation algorithm – finding initial basic feasible solution using Northwest corner rule, Least cost cell and Vogel's approximation method. Optimizing a transportation model. Assignment model: Introduction, Formulation, Hungarian algorithm	10 Hours
UNIT 3	
Network Analysis: Introduction, scope, definitions, Minimal spanning tree problem, Shortest-Route problems, Maximal-flow problems. Project management-CPM/PERT. Game Theory: Introduction, Two-person zero-sum game, saddle point, pure and mixed strategy, Dominance rule, graphical solution, formulation and solution as an LPP.	10 Hours
UNIT 4	
Dynamic Programming: Introduction, characteristics of dynamic programming, dynamic programming approach to Capital allocation problem, Knap Sack and Travelling Salesman problem. Simulation: Introduction, Basic steps in Simulation, Monte Carlo Simulation. Queuing Theory: Introduction, general structure and performance measures of queuing system, cost analysis, Markovian Poisson-exponential single server infinite population model.	10 Hours

TEXTBOOKS	
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.
RE FERENCES	

1	S. D. Sharma; Operations Research: Theory; Methods and Applications; Kedar Nath; 2012
2	J. K. Sharma; Operations Research; Laxmi Publications; 3e; 2009
3	S. R. Yadav, A. K. Malik; Operations Research; Oxford University Press; 1e; 2014
4	P. K. Gupta, D. S. Hira; Operations Research; S Chand; 5e;1976
5	H. A. Taha; Operations Research: An Introduction; Pearson Education, Inc.; 9e; 2014
6	F. S. Hillier, G. J. Lieberman; Introduction to Operations Research; Tata McGraw Hill; 8e; 2005

Prof Elect. 4 (a1) ALTERNATE ENERGY SOURC ES

Course Code	ME641		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. At the end of the course, the student expected to do Understand and analyse 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:

On completing this course students will be able to:

CO 1	Remember basics of commercial and renewable energy sources
CO 2	Understand working principles the various renewable energy sources like wind, solar, biomass, Ocean energy, Fuel cells and MHD systems.
CO 3	Apply Principles of renewable and new energy sources
CO 4	Analyze performance of various alternate Energy Sources

UNIT-1	10 Hrs
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, Solar Angles. 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	11 Hrs

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 (Betz Limit), Wind turbine generators, Average power in wind, Estimation of wind availability, performance evaluation. GEOTHERMAL ENERGY: Prospects of geothermal energy in India. Estimation and nature of Geothermal Energy, geothermal sources & resources like hydrothermal, geopressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy,	
UNIT-3	11 Hrs
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, advantages, limitations and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy. FUEL CELL AND MHD SYSTEMS: Fuel cell principle, types, Advantages and	
disadvantages, conversion efficiency, application. MHD Power Generation Principle, Open cycle and Closed cycle, Design problems and developments, Advantages and limitations	
UNIT -4	10 Hrs
BIO-ENERGY: Biomass as a source of energy, Classification of biomass, Biomass conversion process, Types of gasifiers, Briquetting, Gasification and combustion of biomass ENERGY THROUGH FERMENTATION: Bio-methanation, biogas as a rural energy source, Environmental significance, Biomass production mechanism, Biogas plant and its components, Types of biogas plants.	

TEXTBOOKS	
1	S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 1996
2	Rai, G. D., Non-Conventional Energy Sources, Khanna Publishers, 4th edition, New Delhi, 2005.
3	Wakil, M. M. EL., Power Plant Technology, McGraw Hill Book Company, New York, 1984.
RE FERENCES	
1	Twidell, J. W. and Weir, A. D., Renewable Energy Resources, ELBS Publication, 1986.
2	D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987

Prof. Elec-4 (c)TOOL ENGINEERING					
Course Code	ME642		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To introduce the importance of tool engineering in enhancing productivity and quality.
2. To introduce the applicability of Press tools, Dies, Mould, jigs and fixtures.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the principles of Press tools, Dies, Mould, jigs and fixtures
CO 2	Compare and Select proper tool for precision manufacturing operation
CO 3	Apply the knowledge of jigs and fixtures for turning and milling applications.
CO 4	Compare and select a suitable CNC machining process for a given application

UNIT-1	10 Hrs
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 index able insert, throwaway index able insert types and chip breakers	
UNIT-2	11 Hrs
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 & 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-3	11 Hrs
Die Casting Dies: Terminology: Core, cavity, sprue, slug, fixed and movable cores, finger cams, draft, ejector pins ejector plates, gate, goose nozzle, over-flow, platten, plunger, runner, vent, cooling channels etc. Types of Dies: Single cavity, multi cavity dies, combination dies, unit dies. Die casting alloys, defects in die casting, finishing trimming and inspection of die casting components. Modern trends in die casting dies. 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	

UNIT -4	10 Hrs
Design of Jigs :Functions and differences between jigs and fixtures, advantages in mass	
production, design principles, economics of jigs and fixtures. 3-2-1 Principles of location, 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. Introduction to CNC Machine Tool- Components of CNC machine tool, Drives and controls, Automatic Tool Changers, Automatic Pallet Changers, tool offsets and work offsets, high speed and precision machining concepts	

TEXTBOOKS	
1	B.J.Ranganath; Metal Cutting and Tool Design; Vikas Publishing House Pvt. Ltd.; New Delhi; 2009
2	P. C. Sharma, ―Production Engg. , Khanna publishers. ISBN8121904218
3	P.C. Sharma, ―Machine tools & Tool Design‖. ISBN812192362X
RE FERENCES	
1	Richard Kibbe, John E.Neely, Meyer, White, ―Machine tool practices‖. ISBN8120315006
2	J. Nee; Fundamentals of Tool Design; Society of Manufacturing Engineers; PHI; 2010
3	C. Donaldson, G. H. Lecain, V.C. Goold; Tool design; McGraw Hill Education; 2012
4	L. E. Doyle; Tool engineering: analysis and procedure; Prentice-Hall, 2007
5	HMT; Production Technology; Tata McGraw-Hill Education, New Delhi; 2001
6	Design Data: Data Book of Engineers; PSG College-Kalaikathir, Achchagam Coimbatore; 2012
7	P. C. Sharma; A text book of Production Engineering; S. Chand Publishers; 1999

Prof. Elect 4 (c) FLUID POWER CONTROL					
Course Code	ME643		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	25

Course Objectives:

1. To impart knowledge of applications of governing laws of fluid mechanics and working principle of various components used in hydraulic and pneumatic systems.
2. To provide training in the design of hydraulic and pneumatic circuits for Industrial applications

Course Outcomes:

On completing this course students will be able to:

CO1	Understand the various concepts involved in fluid power control systems.
CO2	Apply the various concepts involved in fluid power control systems to simple hydraulic and pneumatic circuits.
CO3	Analyse the performance of various components in a fluid power circuit.
CO4	Evaluate the performance of various components in a fluid power circuit.

UNIT 1	

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.	12 Hours
UNIT 2	
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	12 Hours
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	
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	12 Hours
UNIT 4	
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.	12 Hours

TEXTBOOKS	
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
RE FERENCES	
1	P. Rohner, Fluid Power and Logic Circuit Design, Macmillan, Hereford, United Kingdom, 1979
2	J. Pippenger, T. Hicks, Industrial Hydraulics, McGraw Hill International Edition, Singapore, 1980
3	T. Jagadeesha, T. Gowda; Fluid Power: Generation, Transmission, and Control, Wiley; 1e; 2013
4	NPTEL notes on fluid power control

Prof. Elect 4 (d) SUPPLY CHAIN MANAGEMENT

Course Code	ME644		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	25

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 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:

On completing this course students will be able to:

CO1	Understand the basic concepts and role of drivers, customer & supplier relationships and performance measures associated with supply chain
CO2	Apply the supply chain and network design concepts in real life situations.
CO3	Analyze case studies on supplierselection, various business models and tourism business in Goa
CO4	Evaluate economics of scale and cost tradeoffs pertaining to drivers of supply chain.

UNIT 1	
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	10 Hours
Chain. Predictable Variability: Managing Supply & Demand, Forward Buying. Supply chain performance measures: Quantitative and qualitative	
UNIT 2	
Facilities: Types of facilities, Role of Network Design in Supply Chain, Factors influencing network design decisions, Framework for Facility Location Decisions, Gravity Location Model. Inventory: Types of Inventory, EOQ, Quantity Discounts, CSL, Safety Inventory, Bullwhip Effect, Vendor Managed Inventory	11 Hours
UNIT 3	
Transportation: Players in Transportation, Modes of Transportation, Design Options, Transportation- Inventory Trade-off, Transportation-Responsiveness Trade-off. 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, EBusiness, B2B, B2C, Logistics, Reverse Logistics, 3PL, 4PL.	11 Hours
UNIT 4	

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: Tourism Supply Chain in Goa, Online Business, Retail chain Store, Supplier Selection using TOPSIS	10 Hours

TEXTBOOKS	
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 and Practices; Biztantra; 2005
3	J. Shah; Supply Chain Management Text and Cases; Pearson Education; 2009
RE FERENCES	
1	G. Raghuram, N. Rangaraj; Logistics and Supply Chain Management: Cases and Concepts; Macmillan India Ltd; New Delhi; 2000
2	K. S. Bhat; Logistics Management; Himalaya Publishing house; 2009
3	T. D. Chaudhuri, I. Ghosh; Application of Multi Criteria Decision Making in Management; Lambert Academy publishing; 2015

Prof. Elect 4 (e) SYSTEM MODELING AND SIMULATION

Course Code	ME645		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO1	Understand various concepts ofof system modeling and simulation

CO2	Apply simulation techniquesin Industrial engineering
CO3	Analyze simulation programs for various applications
CO4	Evaluate different entities of system modeling and simulation

UNIT 1	
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, Generation and application of random numbers with Bernoulli trial, Binomial, Geometric, Pascal, Exponential, Uniform, Normal, Weibull distribution	11 Hours
UNIT 2	
Simulation approaches - Next event, Fixed time increment, Process oriented, Simulation of - Inventory system, Queuing system, Project network, Application of simulation for solving deterministic problems such as evaluation of definite integral, Estimating area of circle, Value of root, Value of imperfect square	10 Hours
UNIT 3	
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	10 Hours
UNIT 4	
Testing the random numbers for various distributions, Estimation of parameters,	11 Hours
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	

TEXTBOOKS	
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
RE FERENCES	
1	S. M. Ross; Simulation; Academic Press, Elsevier; 5e; 2013

THERMAL LABORATORY-II

Course Code	ME650		Credits	1	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	28 hrs/sem	
Scheme of Examination TOTAL =75 marks	IA	TW	TM	P	O
	0	25	0	50	0

Course Objectives:

This course aims to provide a good platform to mechanical engineering students to understand, advanced concepts involved in thermal energy transformation.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the behavior of heat and mass transfer and refrigeration and Airconditioning
CO 2	Apply the knowledge of mathematics, science and engineering fundamentals to study heat transfer, heating, refrigeration and Air-conditioning
CO 3	Analyze performance of heat transfer, heating, refrigeration and Air-conditioning equipment
CO 4	Evaluate performance of heat transfer, heating, refrigeration and Air-conditioning equipment

LIST OF EXPERIMENTS	
Students shall perform at least 8 experiments (at least 4 each from refrigeration and Air-conditioning and Heat Transfer) from the list 1) Thermal Conductivity of A plane wall. 2) Thermal Conductivity of a composite wall. 3) Thermal Conductivity of a Composite cylinder. 4) Analysis of a parallel flow heat exchanger. 5) Analysis of a counter flow heat exchanger. 6) Estimation of Forced Convection heat transfer coefficient. 7) Estimation of Natural Convection heat transfer coefficient. 8) Determination of Stefan Boltzmann Constant 9) Test on Domestic Refrigerator for evaluation of EER 10) Test on vapour compression test rig 11) Test on air conditioning test rig 12) Test on ice plant test rig 13) Test on Heat Pump Test Rig 14) Estimation of cooling load of simple air conditioning system (case study) 15) Visit to any air conditioning/ Refrigeration plant 16) Thermal analysis of refrigeration cycle using suitable software	

Lab -8 MANUFACTURING & AUTOMATION LABORATORY					
Course Code	ME660		Credits	1	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	28 hrs/sem	
Scheme of Examination TOTAL =75 marks	IA	TW	TM	P	O
	0	25	0	50	0

Course Objectives:

1. To practically demonstrate creation of a mechanical component by various machining operations and application of automation tools.
2. To inculcate safe practices during the machining process.

Course Outcomes:

On completing this course students will be able to

1. Apply the concepts of machining operations for the fabrication of simple components. 2. Apply the knowledge of various industrial automation tools

LIST OF EXPERIMENTS

PART A

Machining

Two composite jobs for machining of square or hexagonal nut

Or

One composite job for machining of square or hexagonal nut and one job on Gear cutting.

PART B

Automation

List of Experiments

1. Data Acquisition with Labview
2. Programming with PLC for actuation of single acting and double acting cylinder
3. Control valve characteristics
4. P/I & I/P convertor and demo on Real time temperature/pressure/flow Controllers

TECHNICAL ENGLISH & REPORT WRITING

Course Code	Name of the course		L	T	P	Scheme of Examination						
HM002	TECHNICAL ENGLISH & REPORT WRITING	Hrs/week	3	-	-		Th	S	TW	P	O	TOTAL
		Credits	3	-	-	Duration (min)	3	-	-	-	-	-
						Marks	100	25	-	-	-	125

Course Objectives:

The Students will be able to:

1. Strengthen their listening skill which will help them comprehend lectures and talks in their areas of specialisation.
2. Develop their speaking skills to make technical presentations, participate in group discussions.
3. To help them develop their reading skills by familiarizing them with different types of reading strategies.
4. To equip with writing skills needed for academic as well as workplace contexts.
5. Foster their ability to write convincing job applications and effective reports.

Course Outcomes:

The students after undergoing this course will be able to:

1. Communicate effectively in different situations by using specific, technical vocabulary.
2. Write letters and reports effectively in formal and business situations.
3. Speak convincingly, express their opinions clearly, initiate a discussion, negotiate and argue using appropriate communicative strategies.
4. Write effectively and persuasively and produce different types of writing such as narration, description, exposition and argument as well as creative, critical, analytical and evaluative writing.
5. Read different genres of texts, infer implied meanings and critically analyse and evaluate them for ideas as well as for method of presentation.
6. Face the challenges in the interviews at global level.

UNIT 1	
LISTENING SKILLS : Listening process and practice- exposure to recorded and structured talks, problems in comprehension and retention, note taking practice, listening tests, importance of listening in the corporate world, organization- spatial organization, chronological organization, order of increasing and decreasing importance, styles of communication, accuracy, brevity, clarity, objectivity, impersonal language, professional speaking ability, listening process, hearing and listening, types of listening- superficial, appreciative, focused, evaluative, attentive, empathetic. Barriers to listening- physical, psychological, linguistic, cultural. Speech decoding, oral discourse analysis, effective listening strategies, listening in conversational interaction, listening to structured talks, pre-listening analysis, predicting, links between different parts of the speech, team listening, listening to a telephone conversation, viewing model interviews (face-to-face, telephonic and video conferencing) listening to situation based dialogues, identifying the characteristics of a good listener.	10hrs
UNIT 2	
SPEAKING SKILLS: The speech process, message, audience, speech style, feedback, conversation and oral skills, fluency and self-expression, body language phonetics and spoken English, speaking techniques, word stress, correct stress patterns, voice quality, correct tone, types of tones, barriers to speaking, building self-confidence and fluency, Job interview, interview process, characteristics, of the job interview, pre-interview preparation techniques, interview questions and answers, positive image projection techniques. Group discussion- characteristics, subject knowledge, oral and leadership skills, team management, strategies, and individual contribution. Presentation skills-planning, preparation, organization, delivery. Conversation practice in real life situations, asking for directions (using polite expressions), giving directions (using imperative sentences), Purchasing goods from a shop, Discussing various aspects of a film (they have already seen) or a book (they have already read) Conversation skills with a sense of stress, intonation, pronunciation and meaning –seeking information – expressing feelings (affection, anger, regret, etc.) Speaking – Role play practice in telephone skills – listening and responding, -asking questions -note taking – passing on messages, role play and mock interview for grasping interview skills.	10hrs
UNIT 3	
READING SKILLS : Introduction to different kinds of reading material: technical and non-technical- the reading process, purpose, different kinds of texts, reference material, scientific and technical texts, active and passive reading, reading strategies-vocabulary skills, eye reading and visual perception,, prediction techniques, scanning skills, distinguishing facts and opinions, drawing inferences and conclusions, comprehension of technical material- scientific and technical texts, instructions and technical manuals, graphic information. Note making- tool for study skills, topicalising, organization and sequencing. Making notes from books, or any form of written	09hrs

materials. Summarizing and paraphrasing. Reading a short story or an article from newspaper, Critical reading, Extensive reading activity (reading stories / novels) Speed reading – reading passages with time limit Reading the job advertisements and the profile of the company concerned.	
UNIT 4	
REFERENCING & WRITING SKILLS : Methods of referencing, book references, user guides, references for reports, journal references, magazines and newspapers, unpublished sources, internet references, explaining and elucidating. Writing skills- Effective writing- vocabulary expansion- Effective sentence structure, brevity and clarity in writing- cohesion and coherence in writing, emphasis. Paragraph writing. Letter writing skills - form and structure, style and tone. Inquiry letters, Instruction letters, complaint letters, Routine business letters, Sales letters. Reports, Resumes and Job Applications: Introduction to report writing- Types of reports, information and analytical reports, oral and written reports, formal and non-formal reports, printed forms, letter and memo format, manuscript format, proposals, technical articles, journal articles and conference papers, review and research articles. E-mails, Business Memos, Employment Communication- resume design, resume style. Writing a review / summary of a story / article, Personal letter (Inviting your friend to a function, congratulating someone for his / her success, thanking one's friends / relatives) Writing minutes of meeting – format and practice in the preparation of minutes – Writing summary after reading articles from journals – Format for journal, articles – elements of technical articles (abstract, introduction, methodology, results, discussion, conclusion, appendices, references) Writing strategies.	10hrs
Text Books:	
1. Technical Communication- Principles & Practice by Meenakshi Raman and Sangeeta Sharma, Oxford. 2. Technical writing- B.N. Basu, PHI learning. 3. Professional Communication Skills- Alok Jain, Pravin S.R. Bhatia, A.M. Sheikh. S Chand. 4. Basic Communication Skills for technology- Andrea J Rutherford, Pearson.	

Prof. Core-13CAD/CAM					
Course Code	ME710		Credits	4	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	4	0	0	56 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To impart knowledge of Computer Aided Design and Computer Aided Manufacturing concepts
2. To introduce the basic concepts of automation in Computer Aided Manufacturing Systems and how it can be implemented in modern industry.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic concepts of geometric modeling, Finite Element Method, Computer Graphics and Computer Integrated Manufacturing Systems
CO 2	Write programs for Line drawing, Geometric transformation and Computer Numerical Control using standard software tools
CO 3	Apply the concepts of Geometric construction, Finite Element Methods, robotics and networking for various applications
CO 4	Compare and select a suitable rapid prototyping process for a given application

UNIT-1	14 Hrs
Introduction to CAD/CAM and CIM, Fundamentals of CAD, CAD Software, Geometric modeling – Classification, Construction methods, Constraint based modeling, Other modeling methods, Curve and surface representation, CAD standards, CAD database, Concurrent engineering. Introduction to FEM, General steps of the finite element method, Engineering applications of FEM in various fields, Advantages of FEM, Types of elements. FEM software, Generation of matrix displacement equation for 1-D bar element using direct approach, Solution for displacements, forces, reaction, stresses. Problems on the same.	
UNIT-2	14 Hrs
Introduction to computer graphics, Basic working principle of Plasma, LED and LCD display devices, Bresenham‘s line drawing algorithm (First quadrant only), Cohen- Sutherland line clipping algorithm, Geometric transformations: Numerical on 2D transformation only, Depth buffer algorithm for hidden surface removal, Parametric representation of B-spline and Bezier curves (No numerical).	
UNIT-3	14 Hrs

Introduction to CAM and CIMS, Automation in production systems, Numerical control (NC), NC part programming, Computer controls in NC, Computer Numerical Control,	
Direct Numerical Control, Adaptive control machining systems. Rapid Prototyping (RP), RP procedure, Basic working principles of Stereo lithography, SLS, FDM & LOM processes, The STL file, Applications of RP, Introduction to Reverse Engineering	
UNIT -4	14 Hrs
Automated material handling and storage systems, Robot technology, Robot applications and types, Group Technology (GT), Lean production and agile manufacturing, Flexible Manufacturing Systems (FMS), Computer-Aided Process Planning (CAPP), Web based manufacturing, Introduction to Industry 4.0 and Industrial Internet of Things, hardware elements & interfaces of networking in CIM. Product Life Cycle Management – Introduction, Phases and Components.	

TEXTBOOKS	
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	D. F. Rogers, J Alan Adams; Mathematical Elements for Computer Graphics; McGraw-Hill Publishing Company Ltd, 2e
5	IbhrahimZeid , R. Sivasubramanium, CAD/CAM, Theory & Practice, Tata McGraw-Hill Publishing Company Ltd.; 2e; 2009
RE FERENCES	
1	T. R. Chandrupatla, A. D. Belegundu; Introduction to Finite Elements in Engineering; Prentice-Hall of India Pvt. Ltd.; 1996
2	N. Krishnamurthy- Introduction to computer graphics --- (TMH)
3	T.K. Kundra, P. N. Rao, N.K. Tewari – Numerical control & computer aided manufacturing --- (TMH)
4	Radhakrishnan P. Subramanyan S, CAD/CAM/CIM, New Age International publishers, 1994
5	Tien Chien Chang, Rolland Wyst, HSU Pin Wang, Computer aided manufacturing, Pearson Education
6	Alasdair Gilchrist, IOT Industry 4.0: The Industrial Internet of Things, Apress, 2016

Prof Elect. 5 (a) REFRIGERATION AND AIRCONDITIONING

Course Code	ME721		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	48 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

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

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand and Illustrate the fundamental principles of refrigeration and air conditioning system.
CO 2	Analyse the various refrigeration systems by applying Thermodynamic principles.
CO 3	Apply refrigeration load calculations for selection of components and refrigerants.
CO 4	Evaluate Coefficient of performance, psychometric properties, heating/cooling load of different HVAC systems.

UNIT-1	10 Hrs
AIR REFRIGERATION SYSTEMS: Bell Coleman cycle, applications. Aircraft air refrigeration systems: Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, Reduced ambient, Regenerative air cooling system, Comparison of these systems based on DART rating. NONCONVENTIONAL REFRIGERATION SYSTEMS: Thermoelectric Refrigeration, Thermo-acoustic Refrigeration, Vortex Tube Refrigeration, steam jet refrigeration.	

UNIT-2	11 Hrs
REFRIGERANTS- Classification of refrigerants, Desirable properties of refrigerants, environmental issues, ODP, GWP & LCCP, selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes, refrigerant. VAPOR COMPRESSION REFRIGERATION SYSTEM: Simple vapour compression cycle, Effect of liquid sub-cooling & superheating, factors affecting the performance of VCRS, methods of improving, use of P-h charts, Limitations of	
simple VCR cycle, Two stage VCR cycle with Water intercooler, flash intercooler & liquid sub-cooler.	
UNIT-3	10 Hrs
LOW TEMPERATURE REFRIGERATION: 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, Application of low temperature. VAPOR ABSORPTION REFRIGERATION: Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Electrolux refrigeration system. Solar VAR system.	
UNIT -4	11 Hrs
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, 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.	

TEXTBOOKS	
1	Refrigeration and air-conditioning – C P Arora, TMH
2	Principles of refrigeration – R J Dossat, Willey Eastern Publication
3	Refrigeration and air-conditioning – W F Stoker and J W Jones, TMH
RE FERENCES	
1	Basic Refrigeration and air-conditioning- P.Ananthanarayana, TMH
2	Refrigeration and air-conditioning- Manohar Prasad, New Age Int (P) Ltd
3	Refrigeration and air-conditioning – R. K. Rajput, S. K. Kataria& Sons
4	Modern Air-conditioning practice – C P Arora, TMH

FINITE ELEMENT METHOD

Course Code	ME722		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the steps in FEM, the principles of theory of elasticity, variation of calculus, matrix algebra & calculus, numerical methods and the various approaches to model FEM problems including weighted residual techniques & Rayleigh Ritz method and review of basic equations in fluid mechanics and heat transfer.
CO 2	Apply the FEM techniques to solve problems in statics, dynamics, structural engineering, heat transfer and fluid flow problems using FEM formulations / FEM techniques
CO 3	Analyze the structural, heat transfer and fluid mechanics problems using FEM formulation.
CO 4	Compute the stresses and displacements in structural problems, heat flow and temperature in heat transfer problems and pressure and flow rate in fluid flow problems.

UNIT-1	11 Hrs

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 – Analysis of Stress and Strain, Equilibrium Equations, Compatibility strain-displacement Equations .Generalized Hooke's Law: Constitution Laws for plane stress & plane strain problems. Strain Energy at a point under given state of stress, Analysis of Elastic Stability of columns using Rayleigh Ritz method. 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 & 1-D Torsion.	
UNIT-2	11 Hrs
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 & 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 &Crout's factorization method.	
UNIT-3	10 Hrs
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. Numericalintegration – Gauss Legendre Quadrature technique	
UNIT -4	10 Hrs
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.	

TEXTBOOKS	
1	T.R. Chandrapatla and A.D. Belegundu; Introduction to Finite Element Method in Engineering; Prentice Hall of India; 2002
2	Abel and Desai; Introduction to the Finite Element Method; CBS Publishers & Distributors; 2005
RE FERENCES	
1	S. Rao; Finite Element method in Engineering; Butterworth-Heinemann, 4th e 2005
2	K.J. Bathe; Finite Element Procedure Prentice-Hall of India Pvt. New-Delhi; 1996

3	C.S. Krishnamoorthy; Finite Element Analysis, Theory and Programming; Tata McGraw-Hill Publishing Company Ltd. New Delhi; 2nd e 2004.
4	S. Moaveni; Finite Element Analysis Theory and Application with ANSYS; Pearson Education Ltd.; 3e 2008.
5	J. N. Reddy; An Introduction to the Finite Element Method; McGraw-Hill Company; 3rd e 2005.

Prof. Elec-5 (d) SIX SIGMA MANAGEMENT					
Course Code	ME723		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO1	Understand the concepts, tools, techniques and methodologies in Six Sigma Management
CO2	Apply Six Sigma concepts tools and techniques and methodologies to practical problems in service and manufacturing sectors.
CO3	Analyze real-life situations for design and continual improvement of product and processes
CO4	Evaluate cases using Six Sigma Methodologies

UNIT 1	

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, and Measurement system analysis using gauge R&R	10 Hours
UNIT 2	
Tools and Techniques used in Six Sigma: SIPOC diagram, Root Cause Analysis, Frequency distribution and Histogram, Run charts,	10 Hours
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.	
UNIT 3	
Design of Experiments (DOE): Factorial designs: Introduction, TwoFactor factorial (2^2) design, Three-Factor Factorial (2^3) Design, ANOVA. Numericals on 2^2 and 2^3factorial designs. Taguchi Method: Taguchi philosophy, Loss function, Signal-to-Noise ratio, experimental design in Taguchi Method, Parameter design.	12 Hours
UNIT 4	
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	10 Hours

TEXTBOOKS	
1	H. S. Gitlow, D. M. Levine ; Six Sigma for Green Belts and Champions; Prentice Hall; First Edition; 2004
2	. Mitra; Fundamentals of Quality Control and Improvement; Wiley; Third edition; 2013
3	D. C. Montgomery; Design and Analysis of Experiments; Wiley; Eighth Edition; 2013

RE FERENCES	
1	P. J. Ross; Taguchi techniques for Quality Engineering; McGraw Hill; Second Edition; 2005
2	T. McCarty, L. Daniels, M. Bremer, P. Gupta; The Six Sigma Black Belt Handbook; McGraw Hill; 2010
3	T. Allen; Introduction to Engineering Statistics and Six Sigma; Springer ; 2008
4	J. ReVelle, J. Moran, C. Cox; The QFD Handbook; John Wiley and Sons; 1998.
5	T. Pyzdek; The Six Sigma Handbook; McGraw Hill; Eighth Edition; 2017
6	G. R. Henderson; Six Sigma Quality Improvement with Minitab; Wiley; Second Edition; 2011.
7	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

Prof. Elec-5 (e)ADVANCED OPTIMIZATIO N

Course Code	ME724		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO1	Understand the applied concept of real life linear and non-linear models, problem formulations, algorithmic complexity and tools to solve these models
CO2	Apply the appropriate technique to solve specific linear and non-linear programming model

CO3	Analyze the complexity of solution procedures used to solve specific linear and non-linear programming model
CO4	Evaluate the performance of various traditional and recent solution techniques used to solve the models

UNIT 1	
Duality theory: Dual linear programs, comparison of primal and dual solutions, economic interpretation of dual problem, Dual simplex method Sensitivity Analysis: Introduction, Modified simplex method, Sensitivity analysis on the cost vector, right hand side vector and the constraint matrix, Introduction of additional variable and constraint. Parametric programming: Parametric cost problem and parametric right hand side problem	12 Hours
UNIT 2	
Goal programming: Formulation with competing objectives and solution	10 Hours
algorithms 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	
UNIT 3	
Non-linear optimisation: 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, Quadratic Interpolation	10 Hours
UNIT 4	
Multi-variables optimization without constraints: Classical method, Powell's Conjugate direction method, Steepest Ascent Descent method, Newton's method, Simplex method. Multi-variables optimization with constraints: KTC conditions, Lagrange's method, Cutting Plane method. Evolutionary algorithms: Introduction to other evolutionary algorithms like Genetic algorithm, Simulated Annealing, Tabu search, Neural networks and Ant Colony Optimization	10 Hours

TEXTBOOKS

1	A. Ravindran, D. Philips and J. J. Solberg, Operations Research: Principles and Practice, John Wiley & Sons Inc., 2e; 2012
2	H. Ellis, S. Sartaj and R. Sanguthevar, Computer Algorithms, Galgotia Publications Pvt. Ltd. 2006
3	S. S. Rao, Optimisation Theory and Applications, Wiley Eastern Limited, 1984
4	P. K. Gupta and D. S. Hira, Operations Research, S Chand., 5e; 1976
5	D. Kalyanmoy, Optimization for Engineering Design: Algorithms and examples, PHI Learning Pvt. Ltd., 2e; 2012
6	S. D. Sharma, Operations Research: Theory, Methods and Applications, Kedar Nath. 2012
RE FERENCES	
1	S. N. Sivanandam and S. N. Deepa, Introduction to Genetic Algorithms, Springer, 1e, 2007
2	S. R. Yadav and A. K. Malik, Operations Research, Oxford University Press, 1e, 2014
3	F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, Tata McGraw Hill, 8e, 2005

Prof.Elec-5 (c) ADDITIVE MANUFACTURING

Course Code	ME725		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	25

Course Objectives:

1. To know the principle methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies
2. To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
3. To introduce the concepts of reverse engineering.
4. To provide an overview the software‘s and design methodology of RP.

.

Course Outcomes:

On completing this course students will be able to:

CO1	Understand the various processes of additive manufacturing, rapid tooling and reverse engineering
CO2	Select the appropriate additive manufacturing and rapid tooling process for a desired application
CO3	Apply the knowledge of Computer aided design and additive manufacturing for engineering and biomedical applications
CO3	Develop a simple prototype using the principle of additive manufacturing

UNIT 1	
Introduction: Need-Classification -Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology – Tooling – Applications. Liquid based and solid based additive manufacturing systems: Classification – Liquid based system –Stereo lithography Apparatus (SLA) Principle, process, advantages and applications –Solid based system –Fused Deposition Modeling –Principle, process, advantages and applications	10 Hours
UNIT 2	
Powder based additive manufacturing systems: Selective Laser Sintering – Principles of SLS process –Process, advantages and applications, Three Dimensional Printing –Principle, process, advantages and applications-Laser Engineered Net Shaping (LENS), Electron Beam Melting. Laminated Object Manufacturing: Principle of operation, LOM materials, process details, Applications. Solid Ground Curing: Principle of operation, Machine details, Applications	11 Hours
UNIT 3	
Concepts Modelers: Principle, Thermal jet printer, Sander_s model market 3- D printer, object Quadra systems, Laser Engineering Net Shaping (LENS) Rapid Tooling :Indirect Rapid tooling -Silicon rubber tooling —Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3D keltool, Direct Rapid Tooling — Direct AIM, Quick cast process, Copper polyamide, Rapid Tool DMILS, Sand casting tooling, soft Tooling vs. hard tooling. Rapid manufacturing process optimization: factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation.	10 Hours
UNIT 4	

Software for RP: STL files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools. Cad & reverse engineering: Basic Concept –Digitization techniques –Model Reconstruction –Data Processing for Additive Manufacturing Technology: CAD model preparation –Part Orientation and support generation –Model Slicing –Tool path Generation. Surface digitizing, surface generation from point cloud, surface modification —data transfer to solid models. Medical and bio-additive manufacturing: Customized implants and prosthesis, Design and production. Bio-Additive Manufacturing-Computer Aided Tissue Engineering (CATE) –Case studies	11 Hours

TEXTBOOKS	
1	Paul F. Jacobs: ―Stereo 1ithography and other RP & M Technologies‖-SME NY, 1996
2	Flham D.T &Dinjoy S.S ―Rapid Manufacturing-Verlog London 2001
3	Terry Wohler_s ―Wohler‘s Report 2000‖-Wohler_s Association 2000
RE FERENCES	
1	Tooling: Technologies and Industrial Applications‖, CRC press, 2000
2	Kamrani A.K. and Nasr E.A., ―Rapid Prototyping: Theory and practice‖, Springer, 2006. 3. Hilton P.D. and Jacobs P.F., ―Rapid
3	Liou L.W. and Liou F.W., ―Rapid Prototyping and Engineering applications : A tool box for prototype development‖, CRC Press, 2007
4	Gebhardt A., ―Rapid prototyping‖, Hanser Gardener Publications, 2003
5	Chua C.K., Leong K.F., and Lim C.S., ―Rapid prototyping: Principles and applications‖, Third Edition, World Scientific Publishers, 2010

Lab 9 CAD/CAM Laboratory

Course Code	ME730		Credits	1	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	0	0	2	28 hrs/sem	
Scheme of Examination TOTAL =75 marks	IA	TW	TM	P	O
	0	25	0	50	0

Course Objectives:

1. To learn the basics of CAD modeling and 1D FEA analysis
2. To learn the basics of CNC programming

Course Outcomes:

The student after undergoing this course will be able to:
1. Draw simple 3D & 2D views of machine parts using a standard CAD software
2. Analyse simple 1D structural problems using a standard FEM software
3. Simulate CNC programs for simple turning and milling operations

LIST OF EXPERIMENTS	
1. CAD: Solid modeling of any six 3-D objects, machine parts/ components using standard CAD software. 2. FEA: One exercise on 1D structural analysis using bar element using a standard FEA software. 3. Two exercises on CNC programming using any simulation software.	

SEMESTER VIII

Prof. Core-14 INDUSTRIAL ENGINEERING AND OPERATIONS MANAGEMENT					
Course Code	ME810		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:
On completing this course students will be able to:

CO 1	Understand the objectives and techniques of Industrial Engineering and Operations Management
CO 2	Apply techniques of Industrial Engineering and Operations Management for improving methods, establishing work standards, productivity improvement and effective management of Operations
CO 3	Analyze work cycles for improving methods and establishing work standards for productivity improvement and Analyze situations using qualitative and quantitative techniques in operations management.
CO 4	Evaluate situations to provide solutions to industrial problems.

UNIT-1	10 Hrs
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.	
UNIT-2	10 Hrs
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, Allowances, Calculation of standard time, Predetermined Motion time study (PMTS). Work Sampling: Definition, procedure, determination of sample size. Wages and Incentives: Wages, 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, Emerson Efficiency plan	
UNIT-3	11 Hrs

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, 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	11 Hrs
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 without shortages. Project Management and Network Analysis: Introduction, Network construction -AON and AOA diagrams, CPM and PERT analysis.	

TEXTBOOKS	
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
RE FERENCES	
1	R. M. Barnes; Motion and Time study - Design and Measurement of Work; Wiley and Sons; New York; 1980
2	J. G. Monks; Operations Management: Theory and Problems; McGraw Hill, New York; 1987
3	A. P. Verma; Industrial Engineering & Management; S. K. Kataria& Sons; 2012.
4	M. Mahajan; Industrial Engineering and Production Management; Dhanpat Rai & Co.; 2014

Prof. Elect. – 7 (a)-ENERGY CONSERVATION AND MANAGEMENT

Course Code	ME821		Credits	3
Scheme of Instructions (Hours / week)	L	T	P	TOTAL
	3	0	0	42 hrs/sem

Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

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

Course Outcomes:

On completing this course students will be able to:

CO 1	Remember basics of General Aspects of Energy Auditing and Management
CO 2	Understand working principles boilers, waste heat recovery systems, cogeneration, insulation and electrical systems.
CO 3	Apply principles of working principles boilers, waste heat recovery systems, cogeneration, insulation and electrical systems.
CO 4	Analyze energy economics and performance of thermal and electric utilities

UNIT-1	10 Hrs
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 - examples for different applications, Energy audit reporting.	
UNIT-2	11 Hrs
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 (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), 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	11 Hrs
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	10 Hrs
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.	

TEXTBOOKS	
1	Energy engineering and management, AmlanChakrabarti, PHI Learning, New Delhi 2012
2	Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.
3	Energy Performance assessment for equipment and Utility Systems Vol. 1 to 4, Bureau of Energy Efficiency, Govt. of India
RE FERENCES	
1	Trivedi P R, Jolka K R, Energy Management, Commonwelth Publications, New Delhi
2	Handbook on Energy Audit and Environment management, Abbi Y. A., Jain Shashank, TERI, New Delhi, 2006
3	Energy management Handbook, 5th Edition, Wayne C. Turner, The Fairmont Press Inc., Georgia.
4	Boiler Operators Guide Fourth Edition, Anthony L Kohan, McGraw Hill

Prof. Elect 6 (a1)-AUTOMOBILE ENGINEERING

Course Code	ME822		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. It aims to provide students with a thorough understanding of the construction and operating principle of modern automobile.

2. It also enables students to familiarize with regulatory norms concerning performance, safety and pollution.

Course Outcomes:
On completing this course students will be able to:

CO 1	Understand the need functioning and purpose of various automotive system.
CO 2	Applying Automobile engineering solutions to performance pollution and safety norms.
CO 3	Analyze the vehicle performance in various scenarios.
CO 4	Evaluate automotive solutions to Performance, pollution and safety.

UNIT-1	11 Hrs
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, Single plate clutch, Diaphragm spring clutch, Multi-plate clutch, Semi Centrifugal, Centrifugal and Electro-Magnetic clutches. Fluid Coupling.	
UNIT-2	10 Hrs
Gearbox: Necessity of gear box, Sliding Mesh, Constant mesh, Synchromesh, Torque convertor, Epicyclic gear box, Transfer Case and Four wheel drive system, Overdrive. 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. Vehicle Performance: Power for propulsion, Traction and Tractive effort, Acceleration, Gradiability and Drawbar pull.	
UNIT-3	11 Hrs

Steering System: Condition for true rolling motion, steering geometry, and General arrangement of a Steering System. 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, Hydraulic 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, Independent Rear suspension. Brakes: Functions and Requirements of Brakes, Types of brake systems, Stopping distance. Theory of shoe brakes, Weight transfer, Drum brake, Self-Energized brakes, Disc brake, Hydraulic Brakes, Parking brakes, Air brakes, Power brakes.	
UNIT -4	10 Hrs
Automotive Electrical Systems: Starting system, Battery, Starting Motor. Charging system, 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. Automobile Air Conditioning: Introduction, Construction and working. Automobile sensors: Introduction to temperature sensors, inductive sensors, Position sensors (rotary, linear). Hot wire and thin film air flow sensors, Optical sensor, Oxygen sensors, Light sensors, Rain sensors. Drive/ Steer by Wire Automobiles.	

TEXTBOOKS	
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.
RE FERENCES	
1	W. H. Crouse, Donald L Anglin Author; Automotive Mechanics; Tata McGraw Hill; 2007.
2	M. J. Nunney; Light and Heavy Vehicle Technolog; Elsevier Ltd, 2009.
3	R. K. Rajput; Automobile Engineering; Laxmi Publications Ltd.; 2017.

Prof. Elect-6 (c)INDUSTRIAL AUTOMATION AND ROBOTICS

Course Code	ME823		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

Course Objectives:

1. To introduce students to the structure, performance characteristics, forward & inverse kinematics of an industrial robot.
2. To impart knowledge of machine vision, mobile robots and industrial automation tools.

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the basic concepts in industrial robot, machine vision and mobile robots
CO 2	Understand the working principles of robot grippers, sensors, control systems and drives used in industrial robot
CO 3	Apply the knowledge of PLC programming for an automatic control system
CO 4	Apply spatial transformation to obtain forward kinematics equation and to solve inverse kinematics for robot manipulators

UNIT-1	11 Hrs
Introduction to Automation: Automation in Production systems, Types of Automation: Fixed, Programmable and Flexible, Basic Elements of an Automated System, Levels of Automations. Introduction to basics of SCADA and DCS (Basic concepts only). PLC Applications for control: Pneumatic pistons, Servo motors, Level control in a tank, Detection and Sorting. Basic Concepts in Robotics: Robot anatomy, Basic structure of robots, DOF and degree of motion, Joints and symbols, Work volume and envelope, Robot Body-arm and wrist motions, Resolution, Accuracy, Repeatability and Compliance, Robot Applications	
UNIT-2	10 Hrs
Classification of Robotic Systems: Point to point and Continuous path systems. Grippers, Factors for Gripper selection. Drives and Control Systems: Hydraulic and Pneumatic systems, Control loop of robotic systems. Sensors in Automation and Robotics: Touch sensors, Force and torque sensors, Acoustic sensors, Slip sensors, Proximity & Range sensors, Smart sensors and transmitters, smart actuators.	
UNIT-3	11 Hrs
Robot Arm Kinematics: General Mathematical Preliminaries on Vectors & Matrices, Direct kinematics problem, Denavit-Hartenberg convention and its applications, Inverse	

kinematics solution for 2 axis planar mechanisms and 3-axis spherical. Trajectory planning: Introduction, Steps in Trajectory planning, Necessity of interpolators, Generation of motion commands, Joint space and Cartesian space Techniques.	
UNIT -4	10 Hrs
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 Robotics: Introduction, Key issues for locomotion, Legged mobile robots: Types, leg configuration and stability, Wheeled mobile robots: Wheel configuration & wheel design.	

TEXTBOOKS	
1	Singh, M. Deswal; PLC and SCADA; Laxmi Publications Private Limited; First edition; 2016.
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	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
5	S. Soloman, Sensors and Control systems in Manufacturing; Mcgraw Hill Professionalpublishing, 2e, 2009
6	Roland Siegwart and Illah R. Nourbakhsh, Introduction to Autonomous Mobile Robots, The MIT Press (2004).
RE FERENCES	
1	S. K. Singh; Industrial Instrumentation and Control; McGraw Hill Publications; 2010
2	D. Popovic, V. Bhatkar; Distributed Computer Control Systems in Industrial Automation; CRC Press; 1990.Y. Koran; Robotics for engineers; McGraw Hill Co.; 1985
3	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.
4	R. K. Mittal, I J Nagrath; Robotics and Control; Mcgraw Hill Education; 1e; 2003
5	M. Chidambaram, Computer control of processes; Narosa Publishing house; 2006

Prof. Elec-6 (d)MAINTENANCE ENGINEERING AND MANAGEMENT

Course Code	ME824		Credits	3
	L	T	P	TOTAL

Scheme of Instructions (Hours / week)	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:

On completing this course students will be able to:

CO 1	Understand Reliability, Availability and Maintainability concepts.
CO 2	Apply Reliability, Availability and Maintainability to product or system.
CO 3	Analyze measures of Reliability, Availability and Maintainability.
CO 4	Evaluate performance of product or system based on Reliability, Availability and Maintainability.

UNIT-1	10 Hrs
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	11 Hrs
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, Standby Redundant systems: Perfect switching and Imperfect switching.	
UNIT-3	11 Hrs
Reliability Testing: Product Testing, Reliability Life Testing, Test time calculations, Burnin 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.	
UNIT -4	10 Hrs
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	

TEXTBOOKS	
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
RE FERENCES	
1	K. C. Kapur, L. R. Lamberson; Reliability in Engineering Design; Wiley India; 2011

Prof. Elec-6 (a2)COMPUTATIONAL FLUID DYNAMICS

Course Code	ME825		Credits	3	
Scheme of Instructions (Hours / week)	L	T	P	TOTAL	
	3	0	0	48 hrs/sem	
Scheme of Examination TOTAL = 125 marks	IA	TW	TM	P	O
	25	0	100	0	0

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:
On completing this course students will be able to:

CO 1	Remember basics of thermodynamics, Fluid Mechanics and Heat Transfer
CO 2	Understand working principles of Basic governing equations in integral and differential forms
CO 3	Apply principles of Two Dimensional Steady and unsteady heat conduction, Convection and Incompressible Fluid Flow
CO 4	Analyze CFD as Practical Approach

UNIT-1	11 Hrs
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 (No derivations), Physical interpretation of governing equations, Navier-Stoke‘s model and Euler‘s model of equations.	
UNIT-2	10 Hrs
Basic Discretization Techniques: Introduction to grid generation (Types of grids such as structured, unstructured, hybrid, multiblock, Cartesian, body fitted and polyhedral etc.), 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,	
UNIT-3	11 Hrs
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 (ADI Method). 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, upwind difference approach, 1 D transient convection-diffusion system.	
UNIT -4	10 Hrs

Incompressible Fluid Flow: Solution of Navier-Stoke‘s equation for incompressible flow using SIMPLE algorithms and its variation (SIMPLER), Application to flow through pipe, Introduction to finite volume method. CFD as Practical Approach: Introduction to any CFD tool, steps in pre-processing, geometry creation, mesh generation, selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initializing and solution control for the solver, Residuals, analysing the plots of various parameters (Scalar and Vector contours such as streamlines, velocity vector plots and animation). Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations (RANS), Simple problems like flow inside a 2-D square lid driven cavity flow through the nozzle.	

TEXTBOOKS	
1	John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill
2	J. Tu, G.-H. Yeoh and C. Liu: Computational Fluid Dynamics: A practical approach, Elsevier.
3	A. W. Date: Introduction to Computational Fluid Dynamics, Cambridge University Press, India
RE FERENCES	
1	P. S. Ghoshdastidar: Computer Simulation of Fluid flow and heat transfer, Tata McGraw Hill.
2	C. Hirsch: Numerical Simulation of internal and external flows Vol. 1, John Wiley
3	Tannehill, Anderson, and Pletcher: Computational Fluid Mechanics and Heat transfer, CRC Press.
4	Zikanov, Essential Computational Fluid Dynamics, Wiley India