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
REFERENCES	
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 Multi-Cylinder 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
REFERENCES	
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.
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.

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
REFERENCES	
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
REFERENCES	
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
REFERENCES	
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
REFERENCES	
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
REFERENCES	
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 TRIBOLOGY					
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
REFERENCES	
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	**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 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
REFERENCES	
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 0-7923-7246-8.
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
REFERENCES	
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
REFERENCES	
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, Moment-Generating 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	**12 Hours**

and numericals. *No derivations.***Continuous Probability distributions:** Uniform, Exponential and 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
REFERENCES	
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.
REFERENCES	
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
REFERENCES	
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, Thermo-electric, 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
REFERENCES	
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. Two-dimensional problems in Cartesian co-ordinate system: viz. bending of narrow cantilever beam of narrow cross section under edge load, simply supported beam of narrow cross section under edge load and simply supported beam subjected to uniformly distributed load.	
UNIT-3	**12 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.
REFERENCES	
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
REFERENCES	
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 reliability-based 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 (p-chart, 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 non-conformities (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.
REFERENCES	
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.
REFERENCES	
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 SOURCES**					
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, geo-pressured 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.
REFERENCES	
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
REFERENCES	
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,	**12 Hours**

Vane pumps, Piston pumps, Pump Performance, Pump Selection, Pump Noise. **Hydraulic Actuators and Motors**: Linear Hydraulic Actuators, Mechanics of Hydraulic Cylinders loadings, Limited Rotation Hydraulic Actuators, Gear Motors, Vane Motors, Piston Motors, Hydraulic Motor Performance. **Hydraulic Direction Control**: Check Valves, Shuttle Valves, 2-Way, 3-Way and 4-Way Direction Control Valves, Direction Control Valve Actuation, Hydraulic Circuits, Specifications.	
UNIT 3	
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
REFERENCES	
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	**10 Hours**

Across Supply 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, E-Business, 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
REFERENCES	
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, 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	**11 Hours**

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
REFERENCES	
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 tounderstand, 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 Air-conditioning
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 variousmachining 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 simplecomponents.
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 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.	09hrs
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.