DEPARTMENT OF MECHANICAL ENGINEERING

Scheme of Instruction
and
Syllabus of

For Working Professional
B.E. (Mechanical Engineering)
VII & VIII SEMESTER

***With effected from the Academic Year* 2025-2026**

UNIVERSITY COLLEGE OF ENGINEERING
(AUTONOMOUS)
OSMANIAUNIVERSITY
HYDERABAD–500007, TELANGANA.

SCHEME OF INSTRUCTION EXAMINATION

B.E (Working Professional-Mechanical Engineering)

VII Semester **A.Y.2025-2026**

S.No.	Course Code	Course Title	Scheme of Instruction			Contact hrs/wk	Scheme of Examination		Credits
			L	T	P		CIE	SEE	
1	PC701ME	Thermal Turbo Machinery	3	-	-	3	40	60	3
2	PC702ME	Automation in Manufacturing	3	-	-	3	40	60	3
3	PC703ME	Operations Research	3	-	-	3	40	60	3
4	PC704ME	Production Planning and Control	3	-	-	3	40	60	3
5	Professional Elective-I		3	-	-	3	40	60	3
PRACTICALS									
6	PC751ME	Thermal Engineering Lab-II	-	-	2	2	25	50	1
7	PC752ME	CAM and Automation Lab	-	-	2	2	25	50	1
8	PC753ME	Seminar	-	-	4	4	50	-	2
9	PW751ME	Project Work-I	-	-	8	8	50	-	4
Total			15	-	16	31	350	400	23

Course Code	Professional Elective-I
PE711ME	Nanomaterials and Technology
PE712ME	Cryogenic Technology
PE713ME	Mechanical Vibrations
PE714ME	Finite Element Analysis
PE715ME	Sustainable Energy Technologies
PE716ME	Industry4.0:Principles and Technologies
PE717ME	Non Destructive Testing

Course Code	Course Title						Course Type
PC701ME	**THERMAL TURBO MACHINERY**						**Core**
Prerequisite	Contact hours per week				**Duration of SEE (Hours)**	**Scheme of Evaluation**	**Credits**
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To learn about formulation of governing equations for compressible fluid flows.
- To understand the design concepts of mechanical devices handling compressible fluids.
- To learn about the functioning of turbo machines and related performance parameters.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. The Students are expected to formulate governing equations of compressible flows and derive relations among fluid flow properties.
2. The Students are expected to be able to predict the compressible flow properties behavior with friction, heat transfer and shock waves.
3. The Students are expected to be able to classify turbo machines and explain working principle of Rotodynamic compressors and calculate performance parameters.
4. The Students are expected to explain classification and working principles of steam turbines, and draw velocity diagrams and calculate performance parameters.
5. The Students are expected to be able to explain working principles of gas turbine cycles and understand methods to improve their efficiency. They should be able to understand working principles and performance parameters of Jet and Rocket Propulsion Systems.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	1					1			1	
CO2	3	3	3	3	3					1		1	1	
CO3	3	3	3	3	2					1		1	1	
CO4	3	3	3	3	3		1			2		1	1	
CO5	3	3	3	3	3		2			2	1	1	1	1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction to compressible flows: bulk modulus and coefficient of compressibility, acoustic velocity, mach number, pressure field created by a point disturbance, mach cone and mach angle. Isentropic flow through variable area devices: Energy equation for flow through nozzles and diffusers, Relations connecting stagnation and static properties-enthalpy, temperature, pressure and density. Various regimes of flow. Effect of back pressure on nozzle performance.

UNIT-II

Flow through constant area ducts with friction (Fanno flow): Governing equation, Fanno line, Fanno relations for perfect gas, maximum length of a duct. Flow through constant area ducts with heat transfer (Rayleigh flow): Governing equation, Rayleigh line, Rayleigh relations for perfect gas, choking due to heat transfer. Types of shocks-normal, oblique and expansion. Normal shock waves: Governing equations, Prandtl-Meyer equation, Rankine-Hugoniot relations. Oblique shock waves: Relation between deflection angle and wave angle.

UNIT-III

Definition and classification of turbo machines, Euler's equation for energy transfer. Rotodynamic compressors: General classification, comparison with positive displacement compressors. Concept of shape numb er-selection of impeller. Axial flow compressors: Stage velocity triangles,

enthalpy-entropy diagram, Euler's work input, flow coefficient, blade loading coefficient, relations for static pressure rise in rotor, stator and stage. Stage and polytropic efficiency. Factors affecting stage pressure ratio. Degree of reaction. Surging, stalling and choking. Centrifugal compressors: Elements of a centrifugal stage, stage velocity triangles, performance of different types of impellers- forward, radial and backward swept blades. Enthalpy-entropy diagram, degree of reaction. Slip factor, actual work and stage and polytropic efficiency.

UNIT-IV

Steam Turbines: Classification, flow over blades, impulse and reaction turbines, Pressure and velocity compounding of steam turbines. Impulse steam turbines: Velocity triangles-single and multistage De Laval turbine, effect of blade friction, axial thrust, effect of blade speed ratio on stage and blade efficiency. Partial Admission, height of turbine blades. Parson's reaction turbine: Reaction stage analysis, degree of reaction, maximum blade efficiency, representation on enthalpy-entropy diagram. Height of turbine blades.

UNIT-V

Gas turbines: Classification and comparison of open and closed cycles. Thermodynamic Analysis of Brayton/Joule cycle. Methods to improve thermal efficiency of gas turbine cycles: inter cooling, reheat and regeneration. Jet Propulsion: Aircraft propulsion turbo engines: Turbo jet, turboprop, turbofan, ramjet and pulse jet engines. Propulsion performance parameters: Thrust force, thrust power and thrust Specific fuel consumption. Thrust, propulsion, transmission and overall efficiencies. Rocket Propulsion: Working principle, propulsion efficiency. Types of Rocket engines: Solid propellant and liquid propellant engines.

Suggested Reading:

1. Yahya S M, Fundamentals of compressible flow, New age international publishers, 2018.
2. Balachnadran P, Fundamentals of Compressible fluid dynamics, Prentice Hall of India, New Delhi, 2006.
3. Rathakrishnan E, Gas Dynamics, Prentice Hall of India, New Delhi, 2003.
4. R K Rajput, Thermal Engineering, Laxmi Publications, 2020.
5. Gopalakrishnan G, Prithvi Raj D, A treatise on Turbomachines, Scitech Publications, Chennai, 2002.

Course Code	Course Title						Course Type
PC702ME	**AUTOMATION IN MANUFACTURING**						**Core**
Prerequisite	Contact hours per week				**Duration of SEE**	**Scheme of Evaluation**	Credits
	L	**T**	**D**	**P**	**(Hours)**	**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To understand the importance of automation in the field of machine tool based manufacturing
- To get the knowledge of various elements of manufacturing automation –CAD/CAM, sensors, pneumatics, hydraulics and CNC.
- To understand the basics of product design and the role of manufacturing automation

Course Outcomes: Upon completion of this course, the students will be able to:

1. Understand the fundamental concepts of automation, its importance and classify various types of automation.
2. Interpret the fundamental applications of computer in design, manufacturing and solve Problems using geometric transformation techniques in CAD
3. Illustrate the architecture of a CNC Machine tool and Write CNC Part programs for manufacturing components
4. Describe the working of various automated material handling systems like AGV,AS/RS/ Robots
5. Understand the basic working principles of low cost automation like pneumatic, hydraulic, plc and also gain knowledge on the importance of modelling and simulation.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	3	1	2				1		2			
CO2	3	2	3	1	2				1		2			
CO3	3	2	3	1	2				1		2			
CO4	3	2	3	1	2				1		2			
CO5	3	2	3	1	2				1		2			

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction: Importance of automation, Current trends, CAD, CAM, CIM; Automation in production Systems, Automation Principles and Strategies, Basic elements of an Automated System, Types of automation systems: Fixed or Rigid Automation, Programmable Automation, Flexible Automation, Levels of Automation

UNIT-II

Computer Aided Design: Fundamentals of CAD - Hardware in CAD-Computer Graphics Software: CAD Software: System software, Application Software, Graphic Standards & Exchange formats, CAD database and structure, 2D Geometric Transformations, 3D Geometric Transformation, Geometric modelling: Bezier Curve, Spline curves, NURBS, Surface: Plane surface, ruled surface, Surface of revolution, Tabulated Cylinder, Bezier surface, B-spline surface and solid modelling: CSG and B-Representation.

UNIT-III

Computer Aided Manufacturing: Introduction – Features & Elements of NC, Types of input media and NC Classification, CNC Hardware, NC and NC part programming, Machining Centers, CNC-Adaptive Control systems, FMS: Definition, components of FMS and FMS layouts.

UNIT-IV

Automated Material Handling Systems: Overview of Material Handling Equipment, Principles of material handling, Introduction to working of Automated Guided Vehicles, Automated Storage retrieval systems, Robotics: Definition, classification and types of robot programming.

UNIT-V

Low cost automation: Mechanical & Electro mechanical Systems, Pneumatics and Hydraulics, Illustrative Examples and case studies, Basic structure of PLC and Micro-controllers.
Introduction to Modelling and Simulation: Product design, process route modelling, Introduction to Product Life Cycle Management, PLM Software's, Components of PLM Software

SuggestedReadings:

1. Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, prentice Hall.
2. Serope Kalpakjian and Steven R. Schmid, Manufacturing – Engineering and Technology, 7th edition, Pearson.
3. Yoram Koren, Computer control of manufacturing system, 1st edition
4. Ibrahim Zeid , CAD/CAM : Theory & Practice, 2nd edition.
5. Radhakrishnan, P. Sbramanyam, S.Raju.v, —CAD/CAM/CIM, New Age International (P) Ltd, 2nd Edition.

Course Code	Course Title						Course Type
PC703ME	**OPERATIONS RESEARCH**						**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To understand the terms used in OR, model the given problem
- To learn various types OR models to solve different problems
- To learn various network models and how to use them
- To understand the concepts of Inventory models and sequencing models and develop them
- To solve queuing problems and understand concepts of Integer programming and goal programming.

Course Outcomes: Upon successful completion of this course, the student will be able to

1. To understand the basics of OR, including mathematical modeling, feasible solutions and optimization using LPP
2. To formulate and solve transportation and assignment problems
3. To develop network models and solve for industrial projects
4. To apply Inventory models , sequencing models in industry
5. To model and solve queuing problems.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	2	1							1	1	
CO2	3	3	1	2	1						3	1	1	
CO3	3	3	1	2	1							1	1	
CO4	3	3	1	2	1							1	1	
CO5	3	2	1	2	1							1	1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT- I

Introduction: Operations Research models: Characteristics, applications, and limitations. Linear Programming Problem: Introduction, Basic Assumptions, Formulation, graphical method, simplex method, Big M and Two-Phase method. Duality principle, Primal and Dual Problems, Sensitivity Analysis and Economic Interpretation.

Integer programming: Introduction, Types of Integer programming, Branch and bound methods

UNIT-II

Transportation Assignment Models – Traveling Salesman problem – Networks models – Shortest route – Minimal spanning tree – Maximum flow models – CPM and PERT networks – Critical path scheduling – float calculation and its importance–Cost reduction by Crashing the activity.

UNIT-III

Sequencing models: Introduction, General assumptions, processing n jobs through 2 machines, processing 'n' jobs through m machines, processing 2 jobs through m machines.

Inventory models – Economic order quantity models – Quantity discount models – Stochastic inventory models – discount models – Inventory control models in practice.

Queueing models– Single server and multi-server models – Poisson input – Exponential service – Constant rate service – Infinite population

Unit-IV

Decision models: Game Theory- Introduction, Characteristics of Game Theory, Two Person, Zero sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, mx2), Algebraic and graphical methods.

Replacement models – Models based on service life – Economic life – Single / Multi variable search technique

Dynamic Programming: Introduction- Terminology, Bellman's principle of optimality- Applications of Dynamic programming- shortest path problem- linear programming problem.

UNIT-V

Nonlinear programming:

Unconstrained Nonlinear programming: One-dimensional search, derivatives, Taylor series, and conditions for local optima, convex/concave functions, and global optimality, Gradient search method

Constrained Nonlinear programming: Constrained nonlinear programming models, convex, separable, quadratic and polynomial geometric programming, Lagrange multiplier methods, Kuhn-Tucker optimality conditions.

Suggested Reading:

1. Hamdy, A. Taha, Operations Research – An Introduction, Seventh Edition, Prentice Hall of India Pvt. Ltd., 2002.
2. Ronald L. Rardin, Optimization in Operations Research, First Indian Reprint 2002, Pearson Education Asia.
3. R. Paneerselvam, Operations Research, Prentice Hall of India Private Ltd., 2002.
4. Singiresu S. Rao, Engineering Optimization Theory of Practice, 3rd edition, New Age International (P) Ltd. Publishers.
5. S.C.Sharma, *Operations Research*, Discovery Publishing House,2006.

Course Code	Course Title							Course Type
PC704ME	**PRODUCTION PLANNING AND CONTROL**							**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To understand the importance of PPC in an organization and the role of forecasting in PPC
- To learn the role of inventory management in PPC and various inventory control techniques
- To understand the concepts of routing and scheduling
- To understand the objectives of line balancing and aggregate planning
- To know the meaning of dispatching and various types of dispatching techniques.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Identify the objectives, functions, applications of PPC and forecasting techniques.
2. Apply different Inventory Control Techniques for determining the optimum inventory.
3. Solve routing and scheduling problems.
4. Illustrate various types of Line Balancing Techniques and Aggregate Planning Strategies.
5. Identify various types of dispatching techniques.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1	1								1	1	
CO2	3	2	1	1								1	1	
CO3	3	2	1	1								1	1	
CO4	3	2	1	1								1	1	
CO5	3	2	1	1								1	1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Definition and Objectives of production Planning and Control – Functions of production planning and control – Elements of production control – Types of production – Organization of production planning and control department – Internal organization of department. Forecasting: Importance of forecasting – Types of forecasting, their uses –General principles of Forecasting –Forecasting techniques– qualitative methods- Jury/Expert Method, Survey of Expert opinion method, Sales force composite method, Survey of buyer's intention method and quantitative Methods-Simple average, moving average, smoothing coefficient, Least Square method.

UNIT-II

Inventory Management: Functions of inventories – relevant inventory costs – ABC analysis – VED analysis – EOQ model – Inventory control systems – P–Systems and Q-Systems Introduction to MRP-I, MRP-II & ERP, JIT inventory, Kanban system.

UNIT-III

Routing & Scheduling: Definition of Routing – Routing procedure –Route sheets – Bill of material – Factors affecting routing procedure. Definition of Scheduling – Activities-Difference with loading, Scheduling types: Forward, Backward scheduling, Job shop scheduling methods – Arrival pattern, processing pattern, number of workers available, machine varieties available, Priority rules for job sequencing FIFO, SPT, SOT, EDD, STR, CR, LISO, Random Orders. Scheduling Techniques Gantt Charts, LOB, Johnson's job sequencing rules-n jobs on 2 machines, n jobs on 3 machines, n jobs on m machines.

UNIT-IV

Line Balancing & Aggregate Planning: Introduction to line balancing, objectives, terms related to line balancing, procedures, simple problems; Introduction to Aggregate Planning, Inputs to aggregate planning, strategies- Line strategy, chase strategy, capacity options, demand options.

UNIT-V

Dispatching: Centralized and Decentralized Dispatching- Activities of dispatcher – Dispatching procedure – follow-up – definition – Reason for existence of functions – types of follow up, applications of computer in production planning and control.

Suggested Readings:

1. Samuel Eilon, "Elements of Production Planning and Control", Universal Publishing Corporation, 1991.
2. Buffa & Rakesh Sarin, "Modern Production & Operations management", 8th edition, Wiley india Pvt. Ltd, 2009.
3. S.N. Chary, "Production & Operations Management", 6th Edition, McGraw-Hill Education, 2019.
4. Krajewski, L.J., and Ritzman, L. P., "Operations management – strategy and analysis", 6th Edition, Prentice-Hall of India Pvt. Ltd, 2003.
5. S.K Sharma, savita Sharma, "Industrial Engineering and Operations Management", Sk Kataria & Sons, 2002.

Course Code	Course Title						Course Type
PE711ME	NANOMATERIALS AND TECHNOLOGY						Professional Elective -I
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	T	D	P		CIE	SEE	
	3	-	-	-	3	40	60	3

Course Objectives:

- Understand the influence of dimensionality of the object at nanoscale on their properties;
- Aware of size and shape controlled synthesis of nanomaterial's and Fabrication.

Course Outcomes: After completion of the course student will be able to

- Understand the science of nanomaterials and technology.
- Understand Nano structures, fabrication and special Nano materials.
- Understand the different methods of synthesis of nonmaterial
- Understand fabrication techniques of nanomaterials

CO-PO Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1		1	1	1		1				
CO2	3	2	2	1		1	1	1		1				
CO3	2	2	2	1		1	1	1		1				
CO4	2	2	2	1		1	1	1		1				
CO5	2	2	1	1		1	1	1		1				

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction: Nanoscale, Properties at Nanoscale, advantages and disadvantages, importance of Nano Technology, Bottom-up and Top-down approaches, challenges in Nano Technology. Metal Nanocrystals, Semiconductor nanomaterials, Carbon nano tubes.

UNIT-II

Materials of Nano Technology: Introduction-Si-based materials, Ge-based materials, Smart materials, metals, Ferroelectric materials, Polymer materials, GaAs & InP (III-V) group materials, Nano tribology and Materials, Principles and analytical techniques of XRD, SEM, TEM and STM/AFM

UNIT-III

Nano Structures: Zero dimensional Nano structure (Nano Particles)- Synthesis procedure, characterization techniques, properties and applications of Nano Particles. One dimensional Nano structures (Nano Wires, Nano Tubes)- Various Synthesis procedure, characterization procedure and principles involved, properties and applications of Nano Wires, Types of Nano Tubes, Synthesis procedure, characterization properties and applications of Nano Tubes.

UNIT-IV

Synthesis of nanomaterials:

Physical Methods: Physcal Vapour Deposition (PVD), Inert gas condensation, Arc discharge, DC sputtering, Ion sputtering, Ball Milling, Molecular beam epitaxy, Electro-deposition,

Chemical Methods: Metal nanocrystals by reduction, Sol- gel, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors/

UNIT-V

Nano Fabrication: Introduction, Basic fabrication techniques (Lithography, thin film deposition, and doping) MEMS fabrication techniques, Nano fabrication techniques (E-beam Nano-imprint fabrication, Epitaxy and strain engineering, Scanned probe techniques).

Suggested Reading:

1. A.K.Bandyopadyay, Nano Materials, New Age Publications, 2007.
2. T. Pradeep, Nano: The Essentials: Understanding Nanoscience and Nanotechnolgy, Tata McGraw-Hill, 2008.
3. Carl. C. Koch, Nano Materials Synthesis, Properties and Applications, Jaico Publishing House, 2008.
4. Willia Illsey Atkinson, NanoTechnology, Jaico Publishing House, 2009.
5. Charles P. Poole, Jr., Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, 2003.
6. G. Cao, Nanostructure and Nanomaterials: Synthesis, Properties and Application Imperial College Press, 2004.

Course Code	Course Title						Course Type
PE712ME	**CRYOGENIC TECHNOLOGY**						**Professional Elective -I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To provide the knowledge of evolution of low temperature science.
- To learn the technology of refrigeration and gas liquefaction.
- To know various equipment used for cryogenic systems.
- To understand the methods of separation and purification systems.
- To familiarize the cryogenic instruments.

Course Outcomes:

1. Identify the cryogenic application and understand material properties.
2. Estimate and analyze the refrigeration and liquefaction for minimum work.
3. Design the various heat exchangers and other components.
4. Describe the methods of separation and purification.
5. Explain about cryogenic instrumentation and Safety aspects.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	1							1		1	
CO2	3	2	2	1							1		1	
CO3	3	2	2	1							1		1	
CO4	3	2	2	1							1		1	
CO5	3	2	2	1							1		1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT–I

Introduction to Cryogenics: Historical development, Applications of cryogenics (Space Technology, Food Processing, Super Conductivity, Electrical Power, Cryobiology, Medicine, Cryo-metallurgy), nuclear, chemical and rocket propulsions.
Properties of Engineering Materials: Solids (Mechanical, Thermal, Electrical and Magnetic properties), Properties of Cryogenic fluids.

UNIT-II

Refrigeration and Liquefaction: Refrigeration and liquefaction principles, Joule-Thomson expansion, Isentropic expansion, Linde- Hampson cycle, Claude cycle and Cascade systems. Magnetic cooling, Striling cycle, Cryocoolers, Philip refrigerators, Solvay refrigerator, Gifford – McMahon refrigerator, pulse tube refrigerator.

UNIT-III

Cryogenic Equipments: Heat exchangers, Compressors, Expanders, Effect of various parameters in performance and system optimization. Various insulations and storage equipment for cryogenic fluids. Industrial storage and Transfer of cryogenic fluids.

UNIT-IV

Separation and Purification Systems: Ideal separation of gases, Characteristics of mixtures, Temperature-Composition diagrams, Enthalpy-Concentration diagrams. Principles of gas separation, Air separation systems, Hydrogen separation systems, Helium separation systems. Gas purification methods.

UNIT-V

Cryogenic Instrumentation and Safety: Properties characterizing cryogenic instrumentation. Temperature measurements, Pressure, flow-rate, Liquid-level. Safety in cryogenic fluid handling, Precautions and Protection measures.

Suggested Reading:

1. Randal F. Barron, Cryogenic Systems, Oxford University Press, New York, 1999.
2. T.M Flynn, Cryogenic Engineering, Maxwell Dekker, 1997.
3. Scoot, Cryogenic Engineering, Van Nostrand Co. Inc. 1985.
4. Mamata Mukhopadhyay, Fundamentals of Cryogenic Engineering, PHI Learning Private Limited, 2010.
5. A.Arkherov, I.Marfenina, Ye.Mikulin, Theory and design of cryogenic systems, Imported Pubn, 1981.

e-Resources:

1. http://nptel.ac.in/

Course Code	Course Title						Course Type
PE713ME	**MECHANICAL VIBRATIONS**						**Professional Elective -I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To gain the knowledge of mathematical modelling of a physical system and applying
- The principles of Newton's Second Law and conservation of energy to derive the equations of motion.
- To familiarize with linear systems with degrees of freedom.
- To study the response of a vibrating system with periodic excitation and understand the principle of vibration isolation.

Course Outcomes:

1. Develop a mathematical model for a physical system and derive the governing differential equations.
2. Determine the natural frequencies of single and two degrees of freedom systems.
3. Determine the effect of damping in real time systems.
4. Determine and analyze the response of machine members or structures in forced vibration with different excitation frequencies.
5. Solve the eigen value problems to identify mode shapes.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	3	2				1			2	1	
CO2	3	3	3	3	3				1			3	1	
CO3	3	3	3	3	2				1			2	2	
CO4	3	3	2	3	3				2			3	2	
CO5	3	3	3	3	3				3			3	2	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Fundamentals of Vibrations Analysis- Introduction; Elements of vibration; vibration analysis Procedure; spring elements-equivalent stiffness; Mass or inertia elements; Damping elements-equivalent damping-Types of damping, Definitions and Terminology, Simple harmonic motion. Free Vibration Analysis-Single Degree of Freedom Systems Undamped Vibrations: Different methods for equation of motion-Newton's Second Law, D'Alembert's Principle. Principle of Conservation of Energy, Rayleigh's method.

Damped Vibrations: Differential equation of motion, critical damping coefficient and damping ratio; Damped natural frequency; Logarithmic decrement; Energy dissipated in viscous damping.

UNIT-II

Forced Vibration Analysis (Single Degree of Freedom System):Response of damped and undamped systems to harmonic excitation; frequency response curve; magnification factor; Harmonic excitation of the base, vibration isolation, transmissibility, force transmission to foundation; response of a damped system under rotating unbalance. Vibration measuring instruments-working principle of Seismic mass, Vibrometer, Accelerometer.

UNIT-III

Damped and Undamped Vibrations: Free and forced vibration analysis of two degree offreedom system- different methods for the formulation of equations of motion, natural frequencies, Principal modes-physical interpretation and orthogonality.

UNIT-IV

Torsional Vibrations: Torsional vibration of one, two and three rotor system, Equivalent shafting, Torsional vibration of a geared system, Coordinate coupling-static and dynamic coupling.

UNIT-V

Numerical methods: Characteristic equation, Eigen values, identification of node and mode shapes. Eigen value method, Influence coefficients.

Suggested Reading:

1. G.S. Grover & Nigam, Mechanical Vibrations, Nem Chand & Bros, 6th edn,1998
2. S.S. Rao, Mechanical vibration, 4th edn, Pearson, 2009
3. Thomson , William T, Theory of Vibration with Application,4th edn, Pearson Education, 2007
4. V.P. Singh , Mechanical vibration, DhanpathRai&Co., 3rd edn,2006
5. Graham Kelley,S., Mechanical vibration – Schaums Outline Series, TMH
6. F.S. Tse, Morse & Hinkle, Mechanical vibration, Allyn and Bacon, 1978

Course Code	Course Title					Course Type	
PE714ME	**FINITE ELEMENT ANALYSIS**						**Professional Elective -I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To understand the theory and application of the finite element method for analyzing structural systems.
- To learn Approximation theory for structural problems as the basis for finite element methods
- To learn formulations for a variety of elements in one, two, and three dimensions. Implementations of element formulations will be examined using Matlab.
- To understand modeling and analysis of structures using planar, solid, and plate elements

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Illustrate the concept of Finite Element Method and realize its limitations.
2. Construct shape functions for 1D, 2D and 3D linear and higher order elements.
3. Applying 1D, 2D and 3D elements to solve different static structural and heat transfer problems.
4. Solve 1D and 2D steady state heat transfer, and 1D eigen value and eigen vector problems.
5. Analyze time dependent heat transfer problems and review of Finite Element analyses softwares.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2		1	2					1	2			
CO2	3	2		2	2					1	2			
CO3	3	2		2	2					1	2			
CO4	3	2		2	2					1	2			
CO5	3	2		2	2					1	2			

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction to Finite Element Method, solution method using FEM, discretisation, Boundary conditions, load application, types of elements comparison, Stress and Equilibrium, Boundary conditions. Strain-Displacement relations. Stress-strain relations. Types of elements used.
Convergence requirements and geometric isotropy. Local, natural and global coordinates. One Dimensional problems: Finite element modeling, coordinates and shape functions.
Potential Energy approach: Assembly of Global stiffness matrix and load vector. Finite element equations, Treatment of boundary conditions. Quadratic shape functions.

UNIT-II

Analysis of trusses and frames: Element stiffness matrix for a truss member. Analysis of plane truss with number of unknowns not exceeding two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node.
Analysis of Beams: Element stiffness matrix for two nodded, two degrees of freedom per node beam element.

UNIT-III

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions.

Finite element modeling of Axisymmetirc solids subjected to Axisymmetric loading with triangular elements.

UNIT-IV

Two dimensional four nodded isoprarametric elements and numerical integration.

Steady state heat transfer analysis: One dimensional analysis of a find and two dimensional analysis of thin plate. Analysis of uniform shaft subjected to torsion.

UNIT-V

Dynamic Analysis: Formulation of finite element mode, element matrices, evaluation of Eigen values and Eigen vectors for a stepped bar and a beam.

Time dependent field problems: Application to one dimensional heat flow in a rod. Finite element formation to three dimensional problems in stress analysis. Introduction to Finite Ele ment Analysis Software.

Suggested Reading:

1. Tirupathi R. Chandraputla and Ashok, D. Belgundu" Introduction to Finite Elements in Engineering", Pearson Education, 2002, 3rd Edition.
2. Rao S.S., "The Finite Element Methods in Engineering", pergamon Press, 1989.
3. Segerlind, L.J. "Applied Finite Element Analysis", Wiley Publication, 1984.
4. Reddy J.N., "An Introduction to Finite Element Method", McGraw-Hill Company, 1984.
5. G. Ramamurty, Applied Finite Element Analysis, I. K. International Pvt Ltd, 2010.

Course Code	Course Title						Course Type
PE715ME	**SUSTAINABLE ENERGY TECHNOLOGIES**						**Professional Elective -I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Outcomes:

1. Understand the concept of energy and its sustainable energy opportunities and resources of the energy.
2. Acquire in-depth knowledge on wind energy and power generation
3. Understand the importance of solar energy conversion technologies for power generation.
4. Realization of global bioenergy potential and scenario of bioenergy in India, biomass conversion technologies.
5. Gain the knowledge of Ocean thermal energy technologies.

CO-PO Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1			1		2		1	1		
CO2	3	2	2	1			1		2		1	1		
CO3	3	2	2	1			1		2		1	1		
CO4	3	2	2	1			1		2		1	1		
CO5	3	2	2	1			1		2		1	1		

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction to Energy Fundamentals: Sustainability Definitions, Principle of sustainability design, engineering, system analysis, Sustainability challenges and opportunities.

UNIT-II

Introduction, Wind Power Energy, Basics of Wind Power Turbine Operation, Energy Generation Capacity of a Wind Turbine, Construction of Wind Turbines, Wind Power Calculations, Advantages and Disadvantages of Wind Power.

UNIT-III

A Brief History of the Photoelectric Phenomenon, Types of Solar Cells, Solar Panel Arrays, Solar Power System Components and Materials, Solar Power System Configuration and Classifications, Storage Battery Technologies, Small-Scale Solar Power Pumping, Designing a Typical Residential Solar Power System, PV and BIPV Technologies, Commercial Applications.

UNIT-IV

Introduction to Biomass Resources, Potential of bioenergy, Composition of Biomass, Biomass Conversion Techniques - Wet Process, Dry Process, Types of Biomass Fuels, Biomass power generation. Biofuels for a sustainable future: Bioethanol, Biodiesel.

UNIT-V

Ocean Thermal Energy Conversion (OTEC): Principle- Lambert Law of absorption - Open and Closed OTEC Cycles -Major problems and operational experience.

Tidal energy: Tide – Spring tide, Neap tide – Tidal range – Tidal Power – Types of Tidal power plant

Suggested Reading:

1. Peter Gevorkian, Ph.D., PE, Sustainable Energy Systems Engineering: The Complete Green Building Design Resource, 1st Edition, McGraw-Hill Education, 2007.
2. Mehmet Kanoğlu, Yunus A. Çengel, John M. Cimbala, Fundamentals and Applications of Renewable Energy, 2nd Edition, McGraw Hills, 2023.
3. D.P. Kothari, K.C. Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, 3rd Edition, PHI Learning, 2022.
4. Bob Everett, Stephen Peake, James Warren, Energy Systems and Sustainability, 3rd Edition, OUP Oxford.
5. R. O'Hayre, S-W. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, John Wiley and Sons, USA, 2005.

Course Code	Course Title						Course Type
PE716ME	**INDUSTRY 4.0: PRINCIPLES AND TECHNOLOGIES**						**Professional Elective -I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- Understand the foundational concepts of Industry 4.0, its historical evolution, and its impact on modern manufacturing systems.
- Explore cutting-edge technologies (IoT, AI, big data) and frameworks shaping Industry 4.0-driven business transformations.
- Design a phased roadmap for adopting smart manufacturing, logistics, and predictive analytics in Industry 4.0.
- Examine the role of IIoT, robotics, and sensor technologies in industrial automation and maintenance.
- Develop strategies to overcome challenges and leverage opportunities in the future workforce and Industry 4.0 ecosystems.

Course Outcomes: Upon completion on this course, students will be able to:

1. Explain the evolution of industrial revolutions and compare Industry 4.0 systems with traditional factories.
2. Analyze the key components (IoT, AI, big data) and frameworks driving Industry 4.0 transformations.
3. Develop a strategic roadmap for implementing smart manufacturing and logistics in Industry 4.0.
4. Evaluate applications of IIoT and advanced robotics in industrial automation.
5. Propose strategies to address workforce and technological challenges in the Industry 4.0 era.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1						1	2		1		
CO2	3	2	1		2				1	2		1		
CO3	3	2	1		2				1	2		1		
CO4	3	2	1		2				1	2		1		
CO5	3	2	1		2				1	2		1		

Correlation rating: Low/Medium/High: 1/2/3 respectively

Unit-I

Introduction, Idea of Industry 4.0, Various Industrial Revolutions, Origin concept of Industry 4.0,Industry 4.0 Production system, How is India preparing for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory.

Unit-II

Trends in Industry 4.0:

Introduction, Main Concepts and Components of Industry 4.0, State of Art Technologies, Proposed Framework for Industry 4.0, Trends of Industrial Big Data and Smart Business Transformation.

Unit-III

Roadmap for Industry 4.0:

Introduction, Proposed Framework for Technology Roadmap: Strategy Phase, Development Phase, Smart Manufacturing, Types of Smart Devices, Smart Logistics, Smart Cities, Predictive Analytics.

Unit-IV

Advances in the Era of Industry 4.0:

Introduction, Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Things, Industrial Robotic Applications- Manufacturing, Maintenance and Assembly, IIoT- Industrial IoT.

Unit-V

The Role of Industry 4.0 and Future Aspects:

Introduction, Challenges & Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.

Suggested Reading:

1. Alp Ustundag, EmreCevikcan, Industry 4.0: Managing The Digital Transformation, Springer, 2018.
2. Christoph Jan Bartodziej, The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gabler, 2017.
3. Alasdair Gilchrist, Industry 4.0 The Industrial Internet of Things, Apress Publisher, 2016.
4. Ovidiu Vermesan and Peer Friess, Designing the industry - Internet of things connecting the physical, digital and virtual worlds, Rivers Publishers, 2016.
5. Arshdeep Bahga, Internet of Things- A Hands On Approach, VPT, 2014.

Online PDF books:

1. Architecting for the Cloud: AWS Best Practices, Amazon Web Services, 2024.
2. Stuart Russell, Peter Norvig, Artificial Intelligence a modern approach, 4th Edition, Pearson Education, 2020.

Course Code	Course Title							Course Type
PE717ME	**NON DESTRUCTIVE TESTING**							**Professional Elective -I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To learn the basic principles, techniques, equipment, applications and limitations of basic NDT methods.
- To learn the selection of appropriate NDT methods.
- To grasp the standards and specifications related to NDT technology.
- To know the developments and future trends in NDT.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. After study of the course, the learner should be able to:
2. Able to understand the basic principles, techniques and equipment of NDT methods
3. Able to analyse and interpret the results from NDT TESTS
4. Able to apply the codes, standards and specifications used in NDT
5. Able to select proper NDT method for inspection of industrial products future trends in NDT.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1						1	2	1	1		
CO2	3	2	1						1	2	1	1		
CO3	3	2	1						1	2	1	1		
CO4	3	2	1						1	2	1	1		
CO5	3	2	1						1	2	1	1		

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Liquid Penetrant Inspection: Principles of penetrant inspection, characteristics of a penetrant, water –washable system, post-emulsification system, solvent-removable system, surface preparation and cleaning, Penetrant application, Development, Advantages limitations, and applications. Magnetic Particle Inspection: Principle, Magnetisation methods, continuous and residual methods, sensitivities, Demagnetisation, Magnetic particles, Applications, Advantages and limitations.

UNIT-II

Eddy Current Testing: Principle, Lift-off factor, and edge effects, Skin effect, Inspection frequency, coil arrangements, inspection probes, types of circuit, reference pieces, phase analysis, display methods and applications.

UNIT-III

Ultrasonic Testing: Generation of ultra sound, characteristics of an ultrasonic beam, sound waves at interfaces, sound attenuation, Display systems, Probe construction, type of display, Inspection techniques, Identification of defects, Immersion testing, Sensitivity & calibration. Reference standards. Surface condition, Applications.

UNIT-IV

Radiography: Principle and uses of Radiography, limitations, Principle, Radiation sources, Production of X-rays, x-ray spectra, Attenuation of radiation, Radiographic equivalence, Shadow formation, enlargement and distortion, Radiographic film and paper, Xeroradiography, fluoroscopy, Exposure factors, Radiographic screens, identification markers and image quality indicators, Inspection of simple shapes, inspection of complex shapes, viewing and interpretation of radiographs, Radiation hazard, Protection against radiation, measurement of radiation received by personnel.

UNIT-V

Acoustic Emission: Physical Principles, Sources of emission, instrumentation and applications. Other NDT Techniques: Neutron radiography, Laser induced Ultrasonics, Surface analysis, Thermography.

Suggested Readings:

1. Barry Hull & Vernon John, "Non Destructive Testing", 1988.
2. HJ.Frissell (Editorial Co-Ordinator) - "Non-Destructive Evaluation and Quality Control" - ASM Hand Book - International Publication, USA, 1989.
3. Dove and Adams, "Experimental stress analysis and motion measurement", Prentice Hall of India, Delhi.
4. J Prasad, C. G. Krishnadas Nair, NON DESTRUCTIVE TEST AND EVALUATION OF MATERIALS, 2 EDITION, McGraw Hill, 2017.
5. Ravi Prakash, Non-Destructive Testing Techniques, New Age International Publishers, 2021.

Course Code	Course Title						Course Type
PC751ME	**THERMAL ENGINEERING LAB-II**						**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	-	**-**	**-**	**2**	**3**	**25** / **50**	**1**

Course Objectives:

- To understand working principles of heat transfer equipment
- To understand the flow phenomena on cascade blades.
- Understand the fundamental applications of measuring instruments in equipment

Course Outcomes:

1. Able to find the performance of compressors, blowers
2. Understand the working of wind tunnel and flow over turbine or compressor blades
3. Able to estimate the heat transfer in various types of heat exchangers
4. Able to find out conductivity of solids and liquids and convection in liquids
5. Able to calculate COP of air-conditioning apparatus

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2	2				1					
CO2	3	3	3	2	2				1					
CO3	3	3	3	2	2				1					
CO4	3	3	3	2	2				1					
CO5	3	3	3	2	2				1					

Correlation rating: Low/Medium/High: 1/2/3 respectively

List of Experiments

1. Determination of static pressure distribution on a turbine blade surface at mid span on low speed wind tunnel.
2. Study on downstream wake profile of a turbine cascade at mid span on low speed wind tunnel.
3. Study on downstream wake profile of a compressor cascade at mid span on low speed wind tunnel.
4. Study of Double pipe Heat Exchanger: Determination of Overall heat transfer coefficient in Parallel and counter flow modes of operation.
5. Study of Finned Tube Heat Exchanger: Determination of Overall heat transfer coefficient in Parallel and counter flow modes of operation.
6. Study of Shell and Tube Heat Exchanger: Determination of Overall heat transfer coefficient in Parallel and counter flow modes of operation.
7. Study of cross flow Heat Exchanger: Determination of Overall heat transfer coefficient.
8. Study on Thermal conductivity of metal rod.
9. Study on Thermal conductivity of liquid.
10. Study on Thermal conductivity of insulating powder
11. Study on performance of Centrifugal blower with forward swept blades.
12. Study on performance of Centrifugal blower with backward swept blades.
13. Heat transfer in Forced Convection.
14. Heat transfer in Natural Convection.
15. Critical Heat flux apparatus (Boiling Heat Transfer)
16. Unsteady State of Heat Transfer.
17. Study on heat pipe demonstrator

18. Study on Stefan Boltzmann apparatus
19. Pressure distribution in convergent air nozzle
20. To conduct experiments on air-conditioning apparatus

Note: At least 10 experiments have to be completed with minimum two experiments from each low speed wind tunnel, Heat exchangers, Centrifugal blower, Nozzle and Heat transfer equipments.

Course Code	Course Title						Course Type
PC752ME	**CAM AND AUTOMATION LAB**						**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	-	**-**	**-**	**2**	**3**	**25**	**50**	**1**

Course Objectives:

- To write CNC part programs and simulate using CAM Simulation Software‘s like CADEM/MASTER CAM or any equivalent software‘s.
- To write and execute robot programming using simulation tools for performing pick and place and stacking of objects etc.
- To conduct basic experiments on Pneumatics, Hydraulics and Electro-Pneumatic systems

Course Outcomes: The students will be able to

1. Gain working knowledge in writing CNC part Program, simulate using CAM software‘s and understand the manufacture components on CNC machines
2. Develop robot programs for simulating various tasks like pick and place, stacking etc., using standard robot simulation software‘s like Robotstudio, Microsoft Robotics Developer Studio or any equivalent software‘s
3. Gain working knowledge in simulation of Pneumatic, Hydraulic and PLC simulator.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2		3					2	2			
CO2	3	2	2		3					2	2			
CO3	3	2	2		3					2	2			
CO4														
CO5														

Correlation rating: Low/Medium/High: 1/2/3 respectively

List of Experiments

1. Generate tool path simulation for basic Step turning/Face turning operation.
2. Generate tool path simulation for basic taper turning operation.
3. Generate tool path simulation for thread cutting operation.
4. Generate tool path simulation for combined drilling and grooving operations
5. Generate tool path simulation for Multiple operations
6. Generate tool path simulation for Milling operations
7. Robot Program simulation for stacking the objects in a palletizer
8. Robot programming for a pick & place.
9. Robot Program for perform a spray painting or any other similar operation using any programming method.
10. Hydraulic equipment simulation using H-Simulator
11. Pneumatic equipment simulation using P-Simulator
12. PLC simulator

Note: At least 10 experiments have to be completed with minimum two experiments from CAM, Robotics, Pneumatic, hydraulic and PLC simulators

Course Code	Course Title							Course Type
PC753 ME	**SEMINAR**							**Practical**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	-	**-**	**-**	4	**-**	**50**	**-**	**2**

Seminar Guidelines

Topic Selection & Preparation

- Students may choose seminar topics in consultation with faculty members.
- Further reading of relevant articles in the chosen domain is mandatory.

Seminar Structure (PowerPoint Presentation)

The presentation must be well-structured and include the following sections:

1. Introduction to the Field
2. Literature Survey
3. Consolidation of Available Information
4. Objectives and Methodology
5. Results, Discussion, and Summary
6. Conclusions
7. References

Seminar Delivery Requirements

1. Presentation Duration:
    - Maximum 30 minutes (20 minutes for PowerPoint presentation + 10 minutes Q&A).
2. Report Submission:
    - A detailed spiral-bound report must be submitted in the prescribed format as per department guidelines.

Additional Notes:

1. The seminar presentation should summarize **at least a few research papers** from **peer-reviewed or UGC-recognized journals**.
2. **Seminar Report Format:**
    - Background of Work
    - Literature Review
    - Techniques Used
    - Prospective Deliverables
    - Discussion on Results
    - Conclusions
    - Critical Appraisal
    - References
3. **Evaluation Panel:** At least **two faculty members** will assess and award marks.
4. **Attendance:** All students must attend weekly seminar presentations (compulsory).

S. No.	Description	Max. Marks
1	Content & Relevance	10
2	Presentation Skills	10
3	Preparation of PPT Slides	05
4	Q&A Session	05
5	Seminar Report (Prescribed Format)	20

Course Code	Course Title							Course Type
PW751ME	**PROJECT WORK-I**							**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	-	**-**	**-**	**8**	**-**	**50**	**-**	**4**

Course Objectives:

- To enhance practical and professional skills.
- To familiarize tools and techniques of systematic Literature survey and documentation
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas

Course Outcomes:

1. Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to real-world problems
2. evaluate different solutions based on economic and technical feasibility
3. effectively plan a project and confidently perform all aspects of project management
4. Demonstrate effective written and oral communication skills

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1									3	1	1		1	
CO2					3				1		3		1	
CO3									1		3		1	
CO4					2				1	3				
CO5														

Correlation rating: Low/Medium/High: 1/2/3 respectively

Project work

***Pre requisites**:*

1. Able to define Problem with specifications
2. Relevant Literature survey, familiarity with research journals
3. Critically evaluate various available techniques to solve a particular problem
4. Able to Plan the work, prepare required graphs, bar (activity) charts and analyse the results and arrive at a solution
5. Prepare and present results in a scientific manner (Presentation - oral and written)
6. The department can initiate the project allotment procedure at the end of VI semester and finalize it in the first two weeks of VII semester.
7. First 4 weeks of VII semester will be spent on special lectures by faculty members, research scholars, post graduate students of the department and invited lectures by engineers from industries and R & D institutions. The objective of these preliminary talks will be to expose the students to real life practical problems and methodology to solve the technical problems.
8. Seminar schedule will be prepared by the coordinator for all the students from 5th week to the last week of the semester which should be strictly adhered to.
9. Each student will be required to:
10. Submit a one-page synopsis before the seminar for display on notice board.
11. Give a 20 minutes presentation followed by 10 minutes discussion.
12. Submit a technical write-up on the talk.
13. At least two teachers will be associated with the Project Seminar to evaluate students for the award of sessional marks which will be on the basis of performance in all the 3 items stated above

SCHEME OF INSTRUCTION EXAMINATION

B.E (Working Professional-Mechanical Engineering)

VIII Semester **A.Y.2025-2026**

S.No.	Course Code	Course Title	Scheme of Instruction			Contact hrs/wk	Scheme of Examination		Credits
			L	T	P		CIE	SEE	
1	PC801ME	Additive Manufacturing Technologies	3	-	-	3	40	60	3
2	PC802ME	Design of Solar Energy systems	3	-	-	3	40	60	3
3	Professional Elective-II		3	-	-	3	40	60	3
4	Professional Elective-III		3	-	-	3	40	60	3
5	Professional Elective-IV		3	-	-	3	40	60	3
6	MC801CE	Environmental Science (Mandatory Course)	3	-	-	3	40	60	--
7	OC801ME	MOOC Course-I	Register for an Online SWAYAM/NPTEL MOOC course, pertaining to Mechanical Engineering, with approval from the BoS (Autonomous),MED, UCE,OU.						3
8	PW851ME	Project Work-II	-	-	16	16	50	100	8
		Total	18	-	16	34	290	460	26

Course Code	Professional Elective-II
PE821ME	Hybrid Vehicle Technology
PE822ME	Robotic Engineering
PE823ME	Machine Learning application
PE824ME	Virtual Reality and Augmented Reality
PE825ME	Product Design and Development
PE826ME	Computational Fluid Flows

Course Code	Professional Elective-III
PE831ME	Waste Heat recovery and Co-generation
PE832ME	Machine Tool Engineering and Design
PE833ME	Mechatronics Systems
PE834ME	Fatigue Creep and Fracture
PE835ME	Advanced Propulsion and Space Science
PE836ME	Total Quality Management
PE837ME	Energy Conservation and Management

Course Corse	Professional Elective–IV
PE841ME	MEMS Design and Manufacture
PE842ME	Theory of Elasticity
PE843ME	Heating Ventilation and Air Conditioning
PE844ME	Sustainable Manufacturing
PE845ME	Bio Mechanics
PE846ME	Supply Chain Management
PE847ME	Entrepreneurship

Semester	III	IV	V	VI	VII	VIII	TOTAL
Credits	17	17	17	20	23	26	120

Course Code	Course Title					Course Type	
PC801ME	**ADDITIVE MANUFACTURING TECHNOLOGIES**					**Core**	
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To understand the fundamental concepts of Additive Manufacturing (AM), its advantages, limitations and classifications.
- To know the working principle, advantages, disadvantages and applications of VatPhoto Polymerization, Material Jetting, Binder Jetting, Material Extrusion powder bed 3fusion AM Technologies.
- To know the various types of STL file errors and other data formats.
- To understand features of various AM software and the concept of Topology optimization in AM.
- To understand the diversified applications of AM.

Course Outcomes: At the end of the course the student will be able to:

1. Interpret the features of Additive Manufacturing (AM) and compare it with conventional CNC Technology.
2. Illustrate the working principle, advantages, limitations and applications of various Additive Manufacturing Technologies.
3. Interpret various types of errors in STL file and other data formats used in AM and identify the role of Topology optimization in AM.
4. Analyze different types of software‟s used in 3D Printing Technology.
5. Apply the knowledge of various AM technologies for developing innovative applications.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2						1				1
CO2	3	2	2	2						1				1
CO3	3	2	3	3	3					1	2		2	
CO4	3	2	2	3	3						2		2	
CO5	3	2	2	2	2						2		2	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT – I

Introduction: Additive Manufacturing fundamentals: Need for time compression in product development, need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, commonly used Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies. Role of AM in Industry 4.0.

UNIT – II

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies: Vat Photopolymerization AM Systems: Photopolymers, photo polymerization Stereo Lithography Apparatus (SLA), Direct Light Processing (DLP) and Continuous Direct Light Processing (CDLP). Material Jetting AM Systems: Material Jetting, Nano particle jetting and Drop-On-Demand (DOD) material jetting, Polyjet Binder Jetting AM Systems: Three dimensional Printing (3DP). Material Extrusion AM Systems: Fused Deposition Modeling (FDM).

UNIT – III

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies:
Powder Bed Fusion AM Systems: Selective laser sintering (SLS), Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM).
Direct Energy Deposition (DED) AM Systems: Laser Engineered Net Shaping (LENS).
Sheet Lamination AM Systems: Laminated Object Manufacturing (LOM) and Ultrasonic Additive Manufacturing (UAM).

UNIT – IV

AM Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid. Tessellated Models, STL file Repairs: Generic Solution, Slicing Algorithms:
Design for AM: Topology optimization and Additive Manufacturing.
AM Software's: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3 D Rhino, 3 D doctor, Flash Print, Object Studio, Cura, ITK Snap, 3 -matic, Simplant, 3-matic, Simplant, MeshLab, Ansys for Additive Manufacturing.

UNIT –V

Additive Manufacturing Applications: AM Applications in Design, Engineering Analysis and Planning, Aerospace, Automotive, Jewelry, Coin, GIS, Arts, Architecture. Medical and Bioengineering Applications, Forensic Science, Anthropology, Visualization of Biomolecules, Electronic industry and Disaster Management.

Suggested Readings:

1. Chee Kai Chua and Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" Fifth Edition, World Scientific Publications, 2017
2. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Springer, Second Edition, 2010.
3. Frank W.Liou, "Rapid Prototyping & Engineering Applications", CRC Press, Taylor & Francis group, 2011.
4. Rafiq Noorani, "Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley & Sons, 2006.
5. C.P. Paul, A.N. Jinoop,Additive Manufacturing: Principles, technologies and Application, McGraw Hill, 2021.

Additional Reading

1 NPTEL Course on Rapid Manufacturing. https://nptel.ac.in/courses/112/104/112104265/

Course Code	Course Title							Course Type
PC802ME	**DESIGN OF SOLAR ENERGY SYSTEMS**							**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To develop the fundamental principle of solar radiation and it's measuring devises.
- To understand the concept of solar cell system and implications of solar cell system for best performance.
- To formulate solar thermal systems and also develop solar hybrid systems for different applications.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Illustrate solar radiation and its physical function of the measuring devices.
2. Compare and contract technologies of solar cell fabrication methods.
3. Calculate the required size of solar cell systems for maximum output in peak hours.
4. Illustrate the solar thermal system for different applications.
5. Evaluate the performance of combined solar thermal and solar cell systems.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	2												2
CO2	2	2			2						1		1	
CO3	2	2	2	2	2						2		1	
CO4	2	2			2						2		1	
CO5	2	2	2	2										2

Correlation rating: Low/Medium/High:1/2/3respectively

UNIT-I

Solar radiation: Properties of sunlight. Sun-Earth Relationships, Absorption by the atmosphere. Peak sun hours, the declination of the Sun, Determination of Solar time, Solar angle, Solar window.

Solar radiation is measuring devices: Pyrheliometers, Pyranometers. Pyrgeometer, Net radiometer, Sunshine recorder, Estimation of Average Solar radiation. Solar irradiance at surfaces

UNIT-II

Solar cells and modules: The function of solar cells from semiconductor physics. Different solar cell technologies and fabrication methods. Concepts for increasing efficiency based on loss analysis. Wavelength sensitivity. Series connection and parallel connection of solar cells to modules. Module function and characteristics. Shading of cells and modules.

UNIT-III

Solar cell systems: System components and their functions. Calculating output and dimensioning of solar cell systems. Concentrated sunlight and solar power (CSP). Properties of optical concentration systems. Solar cells in concentrated sunlight. Overview of the different components in a CSP system and their functions. Design of Photovoltaic Systems

UNIT-IV

Solar thermal: Thermodynamic description of solar collectors. Optical properties of solar collectors and technologies for fabrication. Solar thermal systems for different applications: Solar Water Heating (Active and Passive), Solar Industrial Process Heat, Solar Thermal Power Systems in India and abroad. Storage of solar generated heat. Design of Active Systems by Utilizability Methods, Design of Passive and Hybrid Heating Systems.

UNIT-V

Performance Testing of Solar Collectors:

Governing equations for evaluation of performance. Methods of testing, testing procedures, testing of liquid and air flat plate collectors. Cylindrical, parabolic concentrators. Overall performance of heating panels. Selection of materials- Absorbing heat transfer fluids.

Hybrid systems: Combinations of solar thermal and solar cell systems. Overview of different applications.

Suggested Reading:

1. Magal B.S."Solar Power Engineering", Tata McGraw Hill Publishing Co.Ltd., 1994.
2. Sukhatme S.P.," Solar Energy", 2 Edition, Tata McGraw Hill Publishing Co.Ltd., 2nded, 1996.
3. Garg H.P. and Prakash J., "Solar Energy", Tata McGraw Hill Publishing Co. Ltd., 1997.
4. John A. Duffie, William A. Beckman, "Solar Engineering of Thermal Processes", 4thEdition, John Wiley & Sons Inc., 2013.
5. Mertens Konrad, "Photovoltaics: Fundamentals, Technology and Practice", John Wiley & Sons Inc., 2014.

Course Code	Course Title							Course Type
PE821ME	**HYBRID VEHICLE TECHNOLOGY**							**Professional Elective -II**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives: At the end of the program, the students shall be able to understand:

- Electric vehicle subsystems and components
- Purpose and working principle of the various subsystems
- Electric vehicle performance and costs
- Electric vehicle applications and benefits

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Understand and design various aspect of hybrid vehicle
2. Undertake to maintain the operation and performance of the vehicle
3. Evaluate the hybrid vehicle performance.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3		2	2	1					1			1	2
CO2	3	2	2	2	1					1			1	2
CO3	3	2	2	2	1					1				2
CO4														
CO5														

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

ICE (Internal Combustion Engine) limitations, Understanding of the electric vehicle (EV) and hybrid electric vehicle (HEV);E-Mobility vs. ICE vehicle - Performance, efficiency, emissions, energy, power, cost, convenient ; Vehicle tractive effort vs. torque developed by EV, HEV & ICE; EV & hybrid vehicle classification and their basic features, characteristics, applications.

UNIT-II

EV Components' purpose, working principle, features, types, Performance-Clutch, Torque converter, Automatic transmission, planetary gear, CVT, gear ratio calculation; Driveline & differential - FWD, RWD, 4WD, AWD (Front wheel drive, rear wheel drive, 4-wheel drive, all-wheel drive); Braking system - regenerative braking, mechanical brake, braking force distribution, Architecture examples

UNIT-III

Energy storage devices – Purpose of battery, working principle, features, types, performance-Battery, Ultra capacitor / Super capacitor, Flywheel, Fuel cell,
Hybridization of energy sources

UNIT-IV

Power converter: DC to DC converter - Resistor, transistor, chopper; AC to DC converter - Thyristor, rectifier; DC to AC converter – Inverter

UNIT-V

Electric motor: Classification, their basic understanding; Motor properties, motor losses, a good motor; Working principle, performance characteristics, controls, applications DC motor, BLDC motor (Brushless DC motor), Induction motor, PMSM (Permanent magnet synchronous motor).

Suggested Reading:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC, Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
4. Sandeep Dhameja, ―Electric Vehicle Battery Systems, Newnes, 2000.
5. Stefano Longo Mehrdad Ehsani,Yimin Gao, Modern Electric Hybrid Electric and Fuel Cell Vehicles, Third edition, CRC Press, 2019.

Additional Reading

1 http://nptel.ac.in/courses/108103009.

course Code	Course Title							Course Type
PE822ME	**ROBOTIC ENGINEERING**							**Professional Elective -II**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To provide student with the requisite knowledge of the various sub-disciplines in serial robots such as various robot configurations, kinematics, dynamics, control & manipulation, and computer-based acquisition etc.
- To provide adequate background in both analysis and design of serial robots
- To help students develop robots for needs of industry and society

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Identify and classify various robot configurations with their workspaces and their usage in industry.
2. Perform forward and inverse kinematics operations & determine singularity conditions for various robot configurations.
3. Compare and contrast various techniques available to find forward and inverse dynamic solutions for various general robot configurations.
4. Implement various path planning techniques & control algorithms for computing end effector motions for generalized robotic tasks.
5. Interface various hardware and software components to develop robotic systems for industry &evaluate their performance.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	2	2	1				1		1			1
CO2	3	3	2	2	1				1		1			1
CO3	3	3	2	2	1				2	2	1		1	1
CO4	3	3	2	2	1				2	2	1		1	1
CO5	3	3	2	2	1				2	1	1		1	1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Brief History, Types of robots, Overview of robot subsystems, Robot specifications, joints and its types, types of links, Degrees of freedom of robots, accuracy, precision, resolution and repeatability, Robot classification: kinematic configurations, actuators, control mechanisms, concept of workspace, End effectors and Grippers, Mechanical, Electrical, vacuum and other methods of gripping. Applications of robots, specifications of different industrial robots.

UNIT-II

Rotation matrices, Representation of orientation and translation, Euler angle and RPY representation, Homogeneous transformation matrices, Denavit-Hartenberg notation, representation of absolute position and orientation in terms of joint parameters, direct kinematics.

UNIT-III

Angular velocity and acceleration of joints & links, skew symmetric matrices, Inverse Kinematics, inverse orientation, inverse locations, Singularities, Jacobian, Static force analysis of RP type and

RR type planar robots, Dynamic analysis using Lagrangian and Newton-Euler formulations of RR and RP type planar robots.

UNIT-IV

Trajectory Planning: joint interpolation, task space interpolation, executing user specified tasks, Independent joint control, PD and PID feedback, actuator models, nonlinearity of manipulator models, Computed torque control, force control, hybrid control, neural network based control of manipulator, fuzzy control of manipulator, CNN based control of manipulator.

UNIT-V

Sensors: types of sensors, tactile & non tactile sensors, sensors to measure Position, velocity & acceleration measurement, Optical encoders. Range and Proximity sensing, acoustic, pneumatic, Hall Effect sensor, Eddy current sensors, Force and Torque sensors. Different types of End effectors for industrial Robots.

Vision: Image acquisition, types & components of vision system, Image representation, digitization, binary, gray scale, RGB representation, Image processing, Image segmentation, image smoothening, object descriptors, object recognition. Robots used in general applications like material handling, process applications, assembly operations, inspection applications.

Suggested Reading:

1. Spong and Vidyasagar, Robot Dynamics & Control, John Wiley and Sons, Ed.,1990
2. Mittal and Nagrath, Industrial Robotics, Tata McGraw Hill Publications, 2004.
3. Saha & Subirkumarsaha, Robotics, TMH, India.
4. Asada and Sllotine, Robot analysis and intelligence, BS Publications , India.
5. Fu. K.S., GonZalez R.C., Lee C.S.G. Robotics, Control-sensing vision and Intelligence, McGraw Hill, Int. Ed., 1987.
6. Groover M P, Industrial Robotics, McGraw Hill Publications, 1999.

e-Resources/Software

1. Robotic Operating System (ROS), Open source software, ros.org.com.
2. Robotics toolbox in MATLAB.

Course Code	Course Title					Course Type		
PE823ME	**MACHINE LEARNING APPLICATION**							**Professional Elective -II**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- Understand the importance of data preparation & management in Machine learning applications
- Learn the basics of various statistical tools required in machine learning
- Learn to solve using regression and clustering techniques
- Learn to use concept of ANN and CNN for solving problems
- Learn to use ML and DL for mechanical applications

Course Outcomes: At the end of the course, the student will be able to:

1. Distinguish between supervised and unsupervised problem statements
2. Compare and contrast various Machine Learning and Deep Learning algorithms
3. Apply the concepts of Supervised & Unsupervised Learning to obtain the required results
4. Evaluate the importance of different algorithms used for Machine & Deep learning
5. Apply the concepts of ML and DL to the real-time data for mechanical applications and arrive at the required results.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	2	2	2					2	2			
CO2	2	1		1									1	
CO3	2	2	2	2	2						2	2	2	
CO4	2		2	2	2					2			2	
CO5	2		2	2	2					2				

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Data Preparation: Introduction, types of data, Data preparation -Data selection, Data Pre-Processing-Formatting, cleaning and sampling, Data Transformation-Scaling, Decomposition and Aggregation. Regression: Linear regression, Logistic regression, Multiple regression, Stepwise, overfitting, Regularization

UNIT-II

Supervised Learning: Gradient Descent, Bias and Variance, Support Vector Machine: Hyperplanes, Kernels, Regularization, Large margin classification

UNIT-III

Unsupervised learning: Clustering, k-means algorithm, Principal Component Analysis, Missing Data, choosing clusters

UNIT-IV

Neural Networks: Neurons and biological motivation. Linear threshold units. Perceptrons: representational limitation and gradient descent training. Multilayer networks and backpropagation. Hidden layers and constructing intermediate, Overfitting, learning network structure. Shallow neural networks, problems with shallow networks, importance of Deep Learning, key concepts in Deep Learning,

Practical Considerations of Deep neural networks: hyper parameter tuning, initialisation, regularisation, gradient checking, optimisation algorithms, Convolutional Neural Networks, step by step procedure, Recurrent Neural Networks- step by step procedure, ALEXNET, Autoencoders.

UNIT-V

Mechanical Applications of Machine Learning: ANOVA Analysis of manufacturing processes like forming, welding,

Abrasive machining, Condition Monitoring of rotary and reciprocating equipment, Condition monitoring of wind turbine, bearing fault diagnostics, Automatic car detection,

Suggested Readings:

1. Tom Mitchell, Machine Learning, McGraw Hill, Indian Edition, 2017.
2. Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning: From Theory To Algorithms, Third Edition, Cambridge University Press, 2015.
3. Peter Wlodarczak, Machine Learning and its Applications, 1st Edition, CRC Press, 2021.
4. John D. Kelleher, Deep Learning, The MIT Press, 2019.
5. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning, Packt Publishing, 2017.

Additional Reading

1. Ian Good fellow, Yoshua Bengio, and Aaron Courville, Deep Learning, 2016.
2. Christopher M. Bishop, Pattern Recognition and Machine Learning, SPRINGER, 2009.
3. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
4. Richard Sutton and Andrew Barto, Reinforcement Learning: An Introduction, MIT Press, 2015.

Course Code	Course Title						Course Type
PE824ME	**VIRTUAL REALITY AND AUGMENTED REALITY**						**Professional Elective -II**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- Learn the basics of VR and AR
- Learn how to build objects in Unity IDE
- Learn to build controllers in Unity IDE
- Learn to build environment in Unity IDE
- Learn to generate animated walk in Unity IDE

Course Outcomes: At the end of the course, the student will be able to:

1. Differentiate Virtual and Augmented Realities
2. Understand Virtual reality concepts
3. Develop VR applications using Unity3D
4. Move around the 3D world
5. Run Unity 3D application in VR on a smart phone

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1												
CO2	2	1		1	1					1		1		
CO3	2	1		1	1					1			1	
CO4	2	1		1	1					1			1	
CO5	2	1											1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction to Virtual Reality: Virtual Reality – Types – Virtual Reality Vs Augmented Reality – Applications – Technical skills required

UNIT-II

Building Simple Scenes: Introduction to Unity IDE – Objects and Scale – Creating a simple diorama – VR Device integration

UNIT-III

Gaze Based Control: First person Controller – Third person controller – Navigation in VR application – World space User Interface

UNIT-IV

Physics & Environment: Physics component – physics materials – Raycast – particle effects

UNIT -V

Walk-Throughs: Assembling scenes – Adding photos – Animated walkthrough – optimizing for performance – Using all 360 degrees

Suggested Reading:

1. Tony Parisi, Learning Virtual Reality, O'Reilly Media, 2016
2. Jason Jerald, The VR Book – Human Centered Design for Virtual Reality, Morgan & Claypool, 2015.
3. John Williamson, Charles Palmer, Virtual Reality Blueprints: Create compelling VR experiences for mobile and desktop, Packt Publishing, 2018.
4. Dieter Schmalstieg, Tobias Hollerer, AUGMENTED REALITY: PRINCIPLES AND PRACTICE, First Edition, Pearson Education India, 2016.
5. Jesse Glover, Complete Virtual Reality and Augmented Reality Development with Unity, Packt Publishing, 2019.

Course Code	Course Title						Course Type
PE825ME	**PRODUCT DESIGN AND DEVELOPMENT**						**Professional Elective -II**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives: The student should be able to

- Analyze essential design factors
- Develop product plans by evaluating opportunities, resources, and timelines
- Design modular architectures considering supply chain and platform strategies.
- Validate designs through iterative prototyping and quality testing.
- Implement modern development processes

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Define product design and its role in innovation.
2. Plan products by analyzing opportunities, allocating resources, and translating customer needs into design priorities
3. Design product architectures and apply industrial design principles to optimize functionality, manufacturability, and user experience.
4. Apply Design for Manufacturing (DFM) principles to optimize product cost and quality, and implement effective prototyping strategies to validate designs
5. Apply contemporary product development methodologies

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	1	1	1				1		1			1
CO2	2	2	2	1	1				1		1			1
CO3	2	2	2	1	1				1		1			1
CO4	2	2	2	1	1				1		1			1
CO5	2	2	2	1	1				1		1			1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction to product design, Design by evolution and innovation, Essential factors of product design, Production consumption cycle, Flow and value addition in production consumption cycle, Morphology of design, Characteristics of Successful Product Development, Challenges of Product Development.

UNIT-II

Product planning: Product planning process, identify opportunities, evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process Identifying customer needs: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

UNIT-III

Product architecture: implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, and related system level design issues. Industrial design: Assessing the need for industrial design impact, process, managing and accessing the quality of industrial design.

UNIT-IV

Design for X (DFX): Design for manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors, design for assembly, service and quality.

Prototyping: Prototyping basics, principles of prototyping, technologies, planning for prototypes.

UNIT-V

Product Development: A modern product development process, reverse engineering and redesign product development process, product life cycle, product development teams, Product development planning, Manufacturing and economic aspects of product development, trade-off.

Suggested Reading:

1. Karl T. Ulrich, Steven D. Eppinger, Product Design and Development, 6th Edition, McGraw-Hill Education, 2016.
2. Kevin Otto, K.Wood, Product Design and Development, Pearson Education, 2013.
3. Kenneth B.Kahn, Product Planning Essentials, Yes dee Publishing, 2011.
4. Clive L.Dym, Patrick Little, Engineering Design: A Project-based Introduction, 3rdEdition, John Wiley & Sons, 2009.
5. Kevin Otto, Kristin Wood, Product Design, Indian Reprint, Pearson Education, 2004.
6. Boothroyd G, Dewhurst P and Knight W, Product Design for Manufacture and Assembly, 2nd Edition, Marcel Dekker, New York, 2002.

Course Code	Course Title							Course Type
PE826ME	**COMPUTATIONAL FLUID FLOWS**							**Professional Elective -II**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To understand the equations of fluid flow.
- To learn Finite difference method with heat transfer equations and grid generation.
- To learn Finite volume method and staggered grid.

Course Outcomes: At the end of the course the student will be able to:

1. Establish the governing equations for different types of fluid flow systems.
2. Illustrate method of averaging of turbulent flow properties and classify second order partial differential equations.
3. Devise finite difference equations based on accuracy, type of differencing and analyse their stability.
4. Solve equations using FDM and numerical methods on discretised domain.
5. Apply Finite volume method for basic equations of heat transfer and fluid flow problems.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2	2	2								1	
CO2	3	3	2	2	2					2	1		1	
CO3	3	2	2	2							1		1	2
CO4	3	2	2	2	2					2				2
CO5	3	2	2		2					2				2

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Review of basic equations of fluid dynamics: Continuity, Momentum and Energy equations- Navier-Stokes equations, Reynolds and Favre averaged N-S equations. Heat transfer conduction equations for steady and unsteady flows. Steady convection-diffusion equation.

UNIT-II

Introduction to turbulence, Mixing length model, K-ε turbulence Model.
Classification of PDEs-Elliptic, parabolic and hyperbolic equations. Initial and boundary value problems.

UNIT-III

Concepts of Finite difference methods- forward, backward and central difference. Finite difference solutions-Parabolic partial differential equations. Euler, Crank Nicholson, Implicit methods. Higher order difference methods. Errors, consistency. stability analysis- von Neumann analysis. Convergence criteria.

UNIT-IV

Numerical Methods– Jacobi, Gauss Seidel and ADI methods. 1D and 2D Elliptic partial differential equations Problems. Viscous incompressible flow, Stream function- Vorticity method. Introduction to Grid Generation- Types of grid- O,H,C.

UNIT- V

Introduction to finite volume method. Finite volume formulations for diffusion equation, convection diffusion equation. Solution algorithm for pressure velocity coupling in steady flows, Staggered grid, SIMPLE Algorithm.

Suggested Reading

1. Muralidhar K, Sundararjan T, Computational Fluid Flow and Heat transfer, Narosa Publishing House, 2003.
2. Chung, T J, Computational Fluid Dynamics, Cambridge University Press, 2002.
3. Patankar, S V, Numerical Heat transfer and Fluid flow, Hemisphere Publishing Company, New York, 1980.
4. John D Anderson, Computational Fluid Dynamics, McGraw Hill, Inc., 1995.
5. Pradip Niyogi, Chakrabartty S K, Laha M K, Introduction to Computational Fluid Dynamics, Pearson Education, 2005.

Course code	Course Title							Course Type
PE831ME	**WASTE HEAT RECOVERY AND CO-GENERATION**							**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To learn concepts of waste heat recovery
- To learn the applications of heat exchangers & recuperators in heat recovery
- To understand cogeneration methods

Course Outcomes: Student will be

1. Understand waste heat sources, recovery methods, and how to use it in industries.
2. Design and analyze heat exchangers, including performance calculations and pressure drop evaluation for tube-based systems.
3. Design recuperators using thermodynamic principles, compare types, and select materials based on heat transfer parameters.
4. Understand cogeneration concepts, thermodynamic advantages, efficiency, benefits, costs, and industrial applications.
5. Understand how to capture waste heat and use it in power plants while meeting regulations

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1			1					1		1	1
CO2	3	2	2			1					1		2	2
CO3	3	2	2			1					1		2	2
CO4	3	2	1			1					1		1	1
CO5	3	2	1			1					1		1	1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT I

Definition, Sources, Quantity and quality of waste heat. Technologies for waste heat recovery and utilization. Need of storage systems for waste heat. Utilization of Waste Heat - Continuous and Intermittent. Energy requirements of industry. Various forms of waste heat available.

UNIT II

Overview of heat exchangers. Gas to gas. Gas to liquid and liquid to liquid heat exchangers. Calculation of effectiveness and design of heat exchanger for number of tubes. Pressure drop considerations LMTD and effectiveness -NTU methods.

UNIT III

First and Second law of thermodynamics, and it's effect on design of recuperators. Recuperators - Ceramic, metallic and reradiant recuperators, high temperature recuperators. Concept of porosity, Peclet number superficial velocity, pressure drop, and selection of material for heat storage and recovery.

UNIT IV

Cogeneration - Definition, Two basic cogeneration concepts, thermodynamic advantage, Cogeneration efficiency, potential benefits and costs of cogeneration. Cogeneration -Over view, Industrial application of cogeneration.

UNIT V

Source of waste heat and methods of utilization. Application of Cogeneration to a steam power plant. Identifying the possibilities of extracting energy to run a gas turbine. Integration of Steam turbine and Gas turbine - Power calculations, various types and their applications towards power generation. Quality of steam and its effect on performance. Legislation – Power plant and Industrial fuel use act (FUA) Potential nationwide benefits of Cogeneration, Impact of Cogeneration on fuel use patterns. Legislative, Environment and Institutional Constraints for use of waste heat.

Suggested Reading:

1. Donald Q. Kern, "Process Heat Transfer", McGraw Hill International Editions, Chemical Engineering Series, 1965.
2. Wylen V. and Sonntag, "Fundamentals of Classical Thermodynamics" - SI Version, Wiley Eastern Ltd., 1993.
3. David Hu S., "Handbook of Industrial Energy Conservation", Van Nostrand Reinhold Co., 1983.
4. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
5. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.

Course Code	Course Title						Course Type
PE832ME	**MACHINE TOOL ENGINEERING AND DESIGN**						**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To learn and applications of the basics and working principles of different types of machine tools
- To grasp the knowledge of critical functional and operational requirements of different types of machine tools
- To learn the knowledge of design of different types of machine tools to meet varied functional and operational requirements.

Course Outcomes: Student will be able to

1. Understand the basic working principles of different machine tools with kinematic mechanisms.
2. Distinguish the functional and operational requirements of different machine tools
3. Design speed and feed gear boxes for a particular configuration.
4. Design machine tool structures for strength and rigidity
5. Understand various controls used in machine tools

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	3	2							2		2	2
CO2	2	2	2								2		2	2
CO3	2	2	2	2						1				2
CO4	2	2	2	2						1			1	1
CO5	2	2	2	1									1	1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Basic features: Classification of machine tools-Basic features of construction and fundamental kinematic mechanisms of general purpose, special purpose machine tools, transfer machines, Automatic and N.C. machines. Mechanisms used for converting rotary to linear motion: Mechanisms for intermittent motion.

UNIT-II

Kinematics, Drives of Machine tools: Selection of range of speeds and feeds. Layout in G.P., A.P. and Logarithmic progression, standardization of speeds and feeds. Productivity loss. Selection of highest and lowest speeds, range ratio. Design of ray diagram" and structural diagrams for machine tool gear boxes. Sliding, clustered and clutched drives, Rupport drive.

UNIT-III

Feed gear boxes: Norton and Meander drives pre-selection of speed, stepped and stepless regulation. Strength, rigidity and design analysis: Analysis of beds, frames, columns. Materials for structures. Methods to improve the rigidity of structures. Types of Guide ways-overall compliance of machine tool. Thermal effects-functional accuracy of machine tool.

UNIT-IV

Spindle units: Spindle units of lathe, drilling, milling and grinding machines, materials for spindles. Spindle design. Effect of clearance on the rigidity of spindle. Hydrodynamic, hydrostatic, rolling bearings. Selection of bearings.

UNIT-V

Hydraulic controls: Various controls used in machine tools. Hydraulic and pneumatic systems used in machine tools-positive displacement pumps - properties of fluids — relief valves, check valves, flow control valves, multi-position valves, filters, accumulators. Hydraulic circuit for surface grinding machine, hydro-copying system.

Suggested Reading:

1. Sen G.S., & Battacharya, "Principles of Machine Tools", New Central Book Agency, Calcutta, 1986.
2. Basu S.K., "Design of Machine Tools", Allied Publishers, 1980.
3. Russe W. Henke, "Introduction to Fluid Power Circuits and Systems", Addison Wesley, 1970.
4. N. K. Mehta, Machine Tool Design, Tata McGraw Hill Education Pte. Limited, 2012.
5. CMTI - Machine Tool Design Handbook, Kojo Press, 2024.

Course Code	Course Title							Course Type
PE833ME	**MECHATRONICS SYSTEMS**							**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives

- Learn the architecture of mechatronic systems
- Introduce concept of sensors & actuators to measure & control various physical quantities like volume, pressure, temperature
- Learn to design simple control systems
- Learn PLC programming to build simple control systems

Course Outcomes: At the end of the course the student will be able to:

1. Illustrate the architecture of mechatronic systems.
2. Design some simple measurement systems using different sensors.
3. Demonstrated ability to design basic control systems using different actuators.
4. Execute PLC programs for industrial Applications.
5. Demonstrate an understanding of analogue and digital interfacing.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1					2			1		1
CO2	2	1	1	1					1			1	1	1
CO3	2	2	2	1					1			1	1	1
CO4	2	2	2	2					2			1	1	1
CO5	2	1	1	1					2				1	1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I:

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach.

UNIT-II:

Review of fundamentals of electronics. Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs.

UNIT-III:

Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems.

UNIT-IV:

Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. Description

UNIT-V:
Description of PID controllers. CNC machines and part programming. Industrial Robotics.

Suggested Reading:

1. David Alciatoare, Michael Histand, "Introduction to Mechatronics and Measurement Systems",McGraw Hill, 2002.
2. Boltan, W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", Longman, Singapore, 1999.
3. Devdas Shetty, Richard Klok "Mechatronic system design", 2nd edition, Cengage Learning, 2010.
4. Herbert Taub & Donald Schilling : Digital Integrated Electronics, McGraw Hill International Edition, 1977.
5. Krishna Kant; Computer Based Industrial Control; Prentice Hall of India Pvt. Ltd. 1999.

Additional Resources

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. G.W. Kurtz, J.K. Schueller, P.W. Claar . II, Machine design for mobile and industrial applications, SAE, 1994.
3. T.O. Boucher, Computer Automation in Manufacturing - an Introduction, Chappman and Hall, 1996.
4. Haxkworth, "Programmable Logic Controllers-Programming Methods and its Applications", Pearson India Ltd., 2011.

Course Code	Course Title						Course Type
PE834ME	**FATIGUE CREEP AND FRACTURE**						**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives

- Learn the concepts of fatigue design and testing.
- Understand the factors affecting fatigue strength.
- Conceptualize the theory of brittle fracture and understand the modes of fracture and its measurement.
- Learn the mechanism of creep and its importance in design.

Course Outcomes: At the end of the course the student will be able to:

1. Enumerate the design philosophy and recognize formulate fatigue design.
2. Illustrate the factors affecting fatigue and methods to improve fatigue strength.
3. Evaluate ductile and brittle fracture.
4. Predict the stress field at the crack tip.
5. Calculate and measure creep deformation.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	1	1	1							1	1		
CO2	2	2	1	1							1	1		
CO3	2	2									1	1		
CO4	2	2	1	1							1	1		
CO5	1	2	1	1	1						1	1		

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I:

Design philosophy: Infinite life, Safe life, Fail safe and Damage tolerant design concepts.
Fatigue Design: Cyclic stress and stress reversals, Fatigue and progressive fracture, Endurance limit, Fatigue Tests: Cantilever and Beam type of Fatigue Tests, Axial Fatigue Tests. Influence of mean stress on fatigue: Gerber, Goodman and Soderberg‟s criteria. Effect of compressive cyclic stress on fatigue. Fatigue design formula for axial, bending, torsional and combined loading.

UNIT-II:

Fatigue controlling factors: Effect of frequency, Temperature, size, form, stress concentration factors, Notch, sensitivity & surface conditions, residual stresses. Improvement of fatigue strength by chemical/metallurgical processes such as nitriding, flame hardening, case carburizing. Fatigue strength enhancement by mechanical work : cold rolling, peening, shot peening.

UNIT-III:

Effect of environment: Corrosion Fatigue, Concept of cumulative fatigue damage Fracture Mechanics: Ductile and brittle fracture Theoretical cohesive strength of metals, Griffith Theory of brittle Fracture, Oruron‟s modification to Griffith Theory.

UNIT-IV:

Modes of Fracture: Mode-I, -II and -III, fatigue crack growth, Behaviour of metals, Linear Elastic Fracture Mechanics (LEFM), Stress Intensity Factor(SIF), Stress field near the crack tip, Critical

SIF and Fracture Toughness, Experimental determination of fracture toughness KIC , COD gauges and standard ASTM Tests.
Strain Energy Release Rates (SERR), Elasto-Plastic Fracture Mechanics (EPFM), Plastic zone size and its evaluation, J-Integral Method.

UNIT-V:
Creep Analysis: Definition, Constant stress and constant, strain creep tests. Uniaxial creep tests: Baily‟s Power Law, Creep relaxation: strain hardening and time hardening creep relaxation. Introduction to Creep bending and deflection of simple problems.

Suggested Reading:

1. George E. Dieter, Mechanical Metallurgy, - Mc Graw Hill, NY,1988
2. Joseph Marin, Mechanical Behaviour of Engg. Materials, - Prentice Hall of India, 1966
3. Stephens, R.I. and Fuchs, H.O., Metal Fatigue in Engg. ,- Wiley, NY 2001.
4. Finnie, I. and Heller, W.R., Creep of Engg. Materials, - Mc Graw Hill Book Co., 1959
5. Prasant Kumar, Elements of Fracture Mechanics, McGraw Hill Education, 2017.

Course Code	Course Title							Course Type
PE835ME	**ADVANCED PROPULSION AND SPACE SCIENCE**							**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To learn about gas dynamic concepts of rocket propulsion system
- To learn rocket engine system.
- To learn celestial sphere and its parameters
- learn about Satellites & Remote Sensing

Course Outcomes: Student will be able to

1. Classify different rocket propulsion systems and understand the concept of gas dynamics
2. Understand the working principle of rocket engine system
3. Understand celestial sphere and its parameters

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	2	1		1					1		1	1	
CO2	2	2	1	1								1	1	
CO3	2	2	1	1	1					1	1		1	
CO4														
CO5														

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT I

Advanced Gas Dynamics: Normal shock waves, pitot tubes, moving shock waves, oblique shock waves, reflected shock waves, conical shock waves, hypersonic flow, Newtonian theory, high temperature flows, low density flows.

UNIT II

Advanced Propulsion: Rocket engines - Operation and performance of rocket engines, design and operating parameters - total impulse, thrust, energy and efficiencies, Typical performance values, overview of monopropellant, bipropellant liquid, solid and hybrid rocket propulsion systems, combined cycle propulsion, Electric / Ion propulsion.

UNIT III

Rocket Technology: Flight mechanics, application thrust profiles. Acceleration -staging of rockets, feed systems, injectors and expansion nozzles, typical nozzle designs (cone, bell, plug). Rocket heat transfer and ablative cooling. Testing and Instrumentation. Nuclear thermal rockets, pulsed detonation engines, Solar sails.

UNIT IV

Celestial Sphere: Spherical trigonometry, celestial coordinate systems, Astronomical triangle, Time-Sidereal, apparent and mean solar time. Equation of Time.

Two Body Problem: Formulation, relative motion and solution, Kepler's equation, motions of rockets and artificial satellites, transfer orbits, minimum energy interplanetary transfer orbits, use of parking orbits, Perturbations of artificial satellites due to atmospheric drag and flattening of earth.

UNIT V

Nuclear Processes in the Sun, Solar wind, interaction of solar Wind and Earth's magnetic field, Van Allen radiation belts.

Satellites & Remote Sensing: Orbits, earth segment, space segment, earth station, satellite subsystems, working details of communication and navigational satellites - components, operation and maintenance, meteorological satellites. Principles of remote sensing.

Suggested Reading:

1. Shapiro, "The dynamics and thermodynamics of compressible flow", 1953.
2. Thomas, D. Daman, "Introduction to space: The Science of space flight", Orbit book Co., Rd ed., Malabar, FL, 2001.
3. K.D. Abhyankar, "Astrophysics of the solar systems", University Press (India) Ltd., 1999.
4. Timothy Pratt and Charles, W. Bostian, "Satellite Communications", John Wiley, 1988.
5. Martin Tajmar, Advanced Space Propulsion Systems, Springer Verlag GmbH, 2002.

Course Code	Course Title						Course Type
PE836ME	**TOTAL QUALITY MANAGEMENT**						**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- Develop quality environment to the organization.
- Describe the TQM approach for manufacturing/service organization in length.
- Categories various Quality terms like Tolerance and Variability, PDCA cycle,Crosby's10 points and Deming's14Points.
- Identify international and national Quality awards

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Understand the significance of quality in manufacturing
2. Rectify the deviations in quality in manufacturing
3. Practice the quality standards in the organization

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	2	1	1						1			1	
CO2	2	2	1	1						1			1	1
CO3	2	2	1	1						1		1		
CO4														
CO5														

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Evolution of Quality-Historical Perspective, Basic Concepts of Quality, Vision, Mission and Objectives of an Organization, Corporate Structure in an Organization and Role of Quality. Quality Planning, Quality by Design, Quality Costs and Cost of Failure, Waste Control, How Quality Benefits Business.

UNIT-II

Quality and Competitiveness in Business, Zero Defects and Continuous Improvement, Role of Leadership and Commitment in Quality Deployment, Team Building, Motivation and Rewards, Total Employee Empowerment, Quality Functions-Measurement, Inspection, Testing, Calibration and Assurance.

UNIT-III

Design Control and Conformity, Tolerance and Variability, PDCA Cycle, Juran Trilogy, Crosby's 10 points and Deming's14Points Customers Requirements, Customer-Supplier and Chain Links, Establishing Customer Focus-Customer, Satisfaction, Measurement and Customer Retention.

UNIT-IV

Product Liability, Total Quality Concepts and CWQC, Difference in Western And Japanese Approach of TQM, Basic Philosophy and Fundamental Models of TQM, Total Quality and Ethics.

UNIT-V

Internal Politics and Total Quality Management, Quality Culture, Education and Training Implementing Total Quality Management- An Integrated System Approach Total Preventive Maintenance. Self-Assessment, International/National Quality Awards: Malcolm Baldridge Award, Deming Prize, European Award, Rajeev Gandhi Award, CII Exim Award, Jamna Lal Bajaj Award, Golden Peacock Award.

Suggested Reading:

1. Total Quality Management by N.V.R.Naidu, G. Rajendra New Age International, First Edition, Jan 2006.
2. Total Quality Management by R.S Naagarazan, New Age international,3e,2015.
3. Quality Control & Application by B. L.Hanson &P. M. Ghare, Prentice Hall of India,2004.
4. Total Quality Management by V.S Bagad Technical Publications, First Edition, Jan2008.
5. Total Quality Management by S. Rajaram Dreamtech Press, First Edition, Jan2008.

Course code	Course Title							Course Type
PE837ME	**ENERGY CONSERVATION AND MANAGEMENT**							**Professional Elective -III**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To learn about energy conservation
- To understand sources of loss of power in energy conversion
- To understand Procedure for Comprehensive Energy Conservation Planning
- To understand Industrial energy conservation methods

Course Outcomes: After completion of the course student will be able to:

1. Learn energy conservation principles, efficiency concepts, and how to identify energy waste in real-world systems.
2. Learn to work with heat energy systems (steam, oil, gases), calculate energy values, understand power transmission, and identify energy losses.
3. Understand how fuels produce energy, how machines convert it, and how to calculate power losses
4. Learn to analyze energy waste and apply conservation planning to save costs
5. Gain skills in modeling energy efficiency for industrial systems, from data analysis to forecasting demand.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3		2					3					
CO2	2	2	2		2					2				
CO3	2	2												
CO4	2	2		3						2				
CO5	2	1			3									

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Definition, Principles of Energy Conservation - Maximum Thermodynamic efficiency. Maximum Cost - effectiveness in energy use. Various forms of energy - Heat Mechanical. Electrical energy and Chemical energy. Identification of potential sources of energy losses - Transportion, operation and conversion from one from to another.

UNIT-II

Heat energy and storage - Media of transport of heat energy - steam, oil and flue gases. Calculation of steam quality. Calculation of amount of heat energy available. Recuperators. Constructional details, Selection of materials to store heat energy. Concept of power. Modes of mechanical energy transport - Gears, pulleys, belts, shafts etc., Calculation of power. Sources of loss of power in energy conversion into electricity, potential energy (i.e., pumps).

UNIT-III

Chemical energy - combustion of fuels - petrol, diesel and coal. Loss due to quality of fuel, conversion into other form of energy - boilers, I.C. engines. Calculation related to losses. Electrical energy - Working principle of motors and generators. Calculation of efficiency of generators. Losses during transmission and energy conversion - into mechanical energy, thermal energy. Calculation of effecting parameters.

UNIT-IV

Procedure for Comprehensive Energy Conservation Planning (CECP) -Specifying targets, identifying energy in-efficient facilities. Synthesize evaluation and optimization of alternative conservation measures in view of organization costs. Flow chart of organization's functions. Collection of accountable data. Application of CECP method. An example.

UNIT-V

Industrial energy conservation modeling - Methodology - Definition of production system – A primary copper production system, Model construction - Mathematical Programming. Market penetration, Structure of energy conservation model. Data preparation - coefficients needed in a model, Unit production cost and unit energy requirements. Model exercise, verification and validation. Methodology for forecasting Industrial Energy Supply and Demand.

Suggested Reading:

1. Gottschalk C.M., "Industrial Energy Conservation", John Wiley & Sons, 1996.
2. Chaturvedi P., and Joshi S., "Strategy for Energy Conservation in India", Concept Publishing Co., New Delhi, 1997.
3. A.S. Hovan George Dr. A. Shaji George, Dr. A. Shahul Hameed, Energy Conservation & Management, 1st Book Rivers, 2024.
4. Thipse, Energy Conservation and Management, Narosa Publication, 2014.
5. Benard Makaa, Energy Conservation and Management for Professionals, River Publishers, 2025.

Course Code	Course Title						Course Type
PE841ME	**MEMS: DESIGN AND MANUFACTURE**						**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- This course provides a detailed overview to smart materials, piezoelectric materials structures and its characteristics.
- To study of Smart structures and modeling helps in Vibration control using smart materials in various applications.
- To familiarize with various microelectronic mechanical systems which find extensive usage in industrial applications.
- to understand the principles and concepts of using MEMS, ER & MR Fluids for various applications

Course outcomes: After completion of the course student will be able to

1. Describe the overview of different kinds of smart materials and their applications
2. Explain the principle concepts of Smart materials, structures, Fibre optics, ER & MR Fluids, Biomimetics and MEMS with principles of working.
3. Describe the various fabrication processes of smart materials and MEMS
4. Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication
5. Summarize the methods and uses of Micro fabrications, Biomimetics, types of polymers used in MEMS, Fibre optics, piezoelectric sensing and actuation

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3			1	1							1	2	1
CO2	3		1	1	1							1	2	1
CO3	3		3	1	1							1	2	1
CO4	3		2	1	1							1	2	1
CO5	3		2	1	1							1	2	1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT I

Introduction to smart materials and MEMS: an overview- scaling issues in MEMS -Micro sensors, some examples –Micro actuators, some examples– Micro systems – Examples of smart systems.

UNIT II

Smart composites - piezoelectric materials, shape memory alloys, magnetic materials -Electro and magneto-statics, Electro active polymers and electrostrictive materials - measurement techniques for MEMS.

UNIT III

Fabrication processes - Structure of silicon and other materials Silicon wafer processing; Thin-film deposition, Lithography, Etching, LIGA, Micromachining, Thick-film processing, Smart material processing.

UNIT IV

Mechanics of materials- Stresses and deformation: bars and beams - Micro device suspensions: lumped modelling -Residual stress and stress gradients - Thermal loading; bimorph effect - Vibrations of bars and beams - Gyroscopic effect

UNIT V

Electronics and packing - Semiconductor devices - Signal conditioning for microsystems devices- Vibration control of a beam - Integration of microsystems and microelectronics - Packaging of microsystems.

Suggested Reading:

1. Donald J. Leo, Engineering analysis of smart material systems, 1st Edition, John Wiley Sons, 2007.
2. R.C. Smith, Smart material systems: model development, 1st Edition, SIAM, 2005.
3. S.D. Senturia, Microsystem Design, 2nd Edition, Kluwer Academic Publishers, 2004.
4. Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, 1st Edition, McGraw Hill, 2002.
5. V.K. Varadan, K.J. Vinoy, and S. Gopala krishnan, Smart Material Systems and MEMS: Desig and Development Methodologies, 1st Edition, Wiley, 2006.

Course Code	Course Title							Course Type
PE842ME	**THEORY OF ELASTICITY**							**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To familiarize stress and strain.
- To distinguish plane stress and plane strain analysis.
- To understand problems on bending, torsion, thin wall, thick wall and columns.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Illustrate the basic concepts in continuum mechanics of solids, including of strain, internal force, stress and equilibrium in solids.
2. Implementation of energy principles in solution of strength of materials problems.
3. Derivation of constitutive relations of plane stress and strain.
4. Derivation of stress-strain relations for linearly elastic solids such as beams and plates, and Torsion of shafts.
5. Analyze axisymmetric problems such as cylinders and rotating discs and stability of columns.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2		2	1					1			1		
CO2	2	2	2	1					1			1		
CO3	2	2		1					1			1	1	
CO4	2	2	2	2					1	1			1	
CO5	2	2	2	2						1			1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Analysis of Stress: Stress tensor, Equilibrium equations in Cartesian coordinates, Two dimensional stress at a point and principal stresses. Three dimensional stress at a point and principal stresses. Stresses on an oblique plane in terms of principal stresses

UNIT-II

Analysis of Strain: Strains in terms of compatibility, Generalized Hook‟s Law distortional energy, St. Venant‟s principle. displacements in Cartesian coordinates, Equations of and Lame‟s constants, Strain energy, Dilatational and

UNIT-III

Two dimensional problems: Plane stress, Plane strain problems: Stress function, Bi-harmonic equation, Equilibrium equations, Strain displacement relations and compatibility equations in polar coordinates, Stress concentration.

UNIT-IV

Bending of straight beams and curved beams. Torsion of shafts, Membrane analogy. Bending of plates.

UNIT-V

Axi-symmetric problems, Thick walled cylinders subjected to internal and external pressures, Stresses in composite tubes, Rotating disks of uniform and variable thickness. General treatment of column stability problems.

Suggested Reading:

1. L.S. Srinath, "Advanced Mechanics of Solids", Tata McGraw Hill Publ. Co., 1970.
2. S. Timeshenko & J.N. Goodier, "Theory of Elasticity", Tata McGraw Hill, 1970.
3. A.C. Uguaral, "Advanced Strength and Theory of Elasticity", Elsevier Publication, 1965.
4. S. Singh, "Theory of Elasticity", Khanna Publishers, 1979.
5. Teodor M. Atanackovic, Ardeshir Guran, Theory of Elasticity for Scientists and Engineers, Birkhäuser Boston, 2012.

Course Code	Course Title						Course Type
PE843ME	**HEATING VENTILATION AND AIR CONDITIONING**						**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To impart basic concepts used in the heating ventilation and air conditioning.
- To get basic knowledge of various heating and cooling methods adopted in industry.
- To know the design aspects of duct and duct design
- To understand the working of various components used in the Air conditioning.
- To know the various applications of air conditioning systems.

Course Outcomes: After completion of the course student will be able to:

1. Identify the different heating and ventilation system
2. Estimate and analyze the cooling load from different heat source.
3. Design the various ducts for different arrangements.
4. Explain the various air conditioning accessories and helping devices.
5. Describe the industrial and commercial applications of air conditioning systems.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	1	1	1					1	1	1	2	1
CO2	3	3	2	1	1					1	1	1	2	2
CO3	3	3	3	2	1					1	1	1	2	1
CO4	2	2	2	1	1					1	1	1	2	2
CO5	2	2	2	1	1					1	1	1	2	2

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Air Heating System: Classification- gravity warm heating system, forced warm heating system. Balancing warm air heating system. Advantages and disadvantages of air heating system.
Hot water (Hydronic) heating system: Classification- gravity and forced hot water heating system. Gas boiler, Circulating pump, Radiant heating system.
Fundamentals of good indoor quality need for building ventilation. Type of ventilation system- supply and exhaust. Commercial, Residential and Kitchen ventilation system.

UNIT-II

Cooling Load Estimation: Different heat sources, Sensible heat gain through building structure by conduction, Heat gain from solar radiation, Solar heat gain through outside walls and roofs, Sol air temperature, Solar heat gain through glass areas, Heat gain due to infiltration, ventilation, occupants and appliances. Heat gain from products, lighting and power equipment. Heat gain through ducts. Concepts of heating load calculations.

UNIT-III

Air Distribution System: Classification of duct and duct materials, Pressure in Ducts, Continuity and Bernoulli's equation for Ducts, pressure loss in ducts, pressure loss due to friction in ducts, Friction factor for ducts, Rectangular sections equivalent to circular section, Equivalent length

system for representing the other loss. Duct design and Arrangement Systems. Noise and noise control.

UNIT-IV

Air Conditioning Equipment: Air cleaning and Air-Filters, Humidifiers, Dehumidifiers, Fans and Blowers - types of fans- fan characteristic- Centrifugal fans, Axial fans, Static pressure calculation for selection of motor and fan, Grills and Registers. Chilled water piping, Supply and Return pipe sizing. Chilled water pumps.

UNIT-V

Commercial and Industrial Applications: Air conditioning of Houses, Offices, Hotels, Restaurants, Departmental stores, Theatres, Auditorium, and Hospitals.
Transport air conditioning: Automobile, railways, Marine and air craft.
Special applications: Computers, storage of medicine and vaccine, cold storages, printing, textiles, leather industries and various products and process industries.

Suggested Reading:

1. HVAC Fundamentals Volume-I –James.E Brumbough, Wiley Publications.
2. Ventilation ASHRAE Hand Book
3. A Course in Refrigeration and Air conditioning by Arora & Domkundwar, Dhanpatrai & Co
4. Refrigeration and air Conditioning by R.S. Khurmi& J.K. Gupta , S Chand & Co
5. Jordon & Priester, Principles of Refrigeration and Air Conditioning, Prentice Hall, India.

e- Resources:

1. http://nptel.ac.in/

Course Code	Course Title						Course Type
PE844ME	**SUSTAINABLE MANUFACTURING**						**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- To understand the fundamentals of Sustainable Manufacturing and various tools and techniques of sustainability.
- To know the principles of sustainable design
- To understand the role of customer and user needs assessment for sustainability

Course Outcomes: After completion of the course student will be able to:

1. Summarize the basic concepts in sustainability
2. Apply sustainable engineering design tools for life cycle assessment (LCA) and examine the features of various LCA Software
3. Interpret the Principles of Sustainable Breakthrough Design
4. Summarize the various design concepts for sustainability
5. Identify Customer and User Needs Assessment for sustainable manufacturing

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	1	1	2		1				2	1	2	2	2	
CO2	1	2	2		1				2	1	2	2		2
CO3	1	2	2		1				2	1	2	2	2	
CO4	1	2	2		1					1	2	2	2	
CO5	1	1	2		1				2	3	2	2		

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Basic Concepts in Sustainability, Understanding the language of sustainable engineering design, construction and operation. Natural resources terminology, Carrying capacity, Sustainable development, corporate responsibility, biophysical constraints, environmental management.

UNIT-II

Tools and Techniques of Sustainability, Sustainable Engineering Design Tools – Life cycle analysis, carbon foot printing. Life cycle assessment (LCA), Types of LCA's: baseline, comparative, streamlined .LCA inventory analysis: processor input- output. Hybrid inventory analysis. Sustainable Product Design. Whole Systems design. Light weighting and materials reduction. Designing for a life time. Design for durability, Repair and upgrade, disassembly and recycling. Energy use in design. Reducing energy losses in design.

UNIT-III

Fundamental Concepts &Principles for Sustainable Break through Design Infrastructure for managing flows of materials, energy and activities; sustainable value creation approaches for all stake holders, environmental design characteristics; design changes & continual improvement; inclusive sustainable design principles, crowd sourcing, multiple-objective designs; infrastructures that support system thinking; knowledge management for sustainable design, learning systems and experimentation; smart data systems, understanding variation.

UNIT-IV

Sustainable Design: Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, bio-mimicry, design for reuse, dematerialization, modularization, design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, etc.

UNIT-V

Customer and User Needs Assessment Identification &breakdown structures that describe customers & stakeholders, green marketing, socially conscious consumerism, sources of customer information, collecting information, analyzing customer behavior, translating the voice of the customer, use analysis, structuring customer needs, service gap analysis, prioritizing customer needs, strategic design, Kano technique.

Suggested Reading:

1. Clarke, Abigail & John K. Gershenson, Design for the Life Cycle. Life-cycle Engineering Laboratory, Michigan Technological University, 2006.
2. Finster, Mark P., Sustainable Perspectives to Design and Innovation, 2013.
3. Ramaswamy, Rohit, Design and Management of Service Processes: Keeping Customers for Life, Prentice Hall, 1996.
4. Schmitt, Brent, Customer Experience Management, Wiley and Sons, 2003.
5. J. Paulo Davim, Sustainable Manufacturing, Wiley-ISTE, 2010.

Course Code	Course Title						Course Type
PE845ME	**BIO MECHANICS**						**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**3**

Course Objectives:

- Understand the importance of composition & properties with respect to structure of bones
- Learn to develop viscoelastic models of soft tissues
- Learn to determine the mechanical behavior of passive muscles
- Understand the behavior of muscle force production and transmission
- Learn to optimize the production of muscle force and transmission

Course outcomes: After completion of the course student will be able to

1. Identify various bones with their composition & elastic properties and understand their importance with respect to structural strength of human skeleton.
2. Determine the visco elastic constitutive models of soft issues and further modifying the muscle models as fibre composite materials.
3. Determine the mechanical properties of muscles and tendons.
4. Develop functional relationships between force applied and length & velocity developed in muscles
5. Optimise the muscle force production & transmission.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	3	2								1			
CO2	2	3	2		2					2	1		1	
CO3	2	3	2		2					2	1		1	
CO4	2	3	3		2					2	1		1	
CO5	2	3	3		2					2	1		1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Introduction to Biomechanics – Terminology – Anthropometry – Skeletal Mechanics – Structure of bones – Composition and properties of bones and relationship to structure – Elastic properties of bones – Characterizing elastic anisotropy – Modeling and Remodeling of bones(Wolfe‘s law of bone remodeling)

UNIT-II

Viscoelasticity of soft tissues – Models of viscoelasticity (Maxwell, Voigt, Kelvin)Muscle mechanics – Muscle architecture and mechanics – Muscle fascicles and their arrangement – Fiber architecture in fascicles – Muscle as a fiber reinforced composite – Muscle centroids – Muscle Cross sectional areas (Physiological & Anatomical).

UNIT-III

Properties of tendons and passive muscles – Viscoelastic behavior of tendons – Tendon interaction with surrounding tissues – Mechanical properties of passive muscles.

UNIT-IV

Mechanics of Active muscle: Muscle force production and transmission – Functional relations (Force – length, Force – Velocity curves), History effects in muscle mechanics – Hill‘s model (derivation) – Sliding filament theory

UNIT-V

Muscle coordination – Problem of motor redundancy – Approach to studying muscle force production using optimization (forward and inverse) Exemplary behavior: Dynamics of Reaching – Inverse dynamic modeling.

Suggested Reading:

1. Robert L.Huston, Principles of Biomechanics, CRC Press, 2013.
2. Susan J. Hall, Basic Biomechanics, 6th Edition, McGraw Hill, 2007
3. Bruce M. Koeppen and Bruce A. Stanton, Berne & Levy Physiology, 6th Updated Edition, Mosby Elsevier, 2010.
4. N.A. Abu Osman, Prosthetic Biomechanics in Engineering, CRC Press, 2021.
5. Joseph Hamill, Kathleen M. Knutzen, Timothy R. Derrick, Biomechanical Basis of Human Movement, 4th Edition, Wolters Kluwer, 2015.
6. David A. Winter, Biomechanics and Motor Control of Human Movement
7. Nihat Özkaya and Margareta Nordin, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation
8. Margareta Nordin and Victor H. Frankel, Basic Biomechanics of the Musculoskeletal System

Course Code	Course Title						Course Type
PE846ME	**SUPPLY CHAIN MANAGEMENT**						**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To understand the basics of supply chain management and its decision-making process.
- To learn about the key drivers that affect supply chain performance and how to measure them.
- To explore how to design supply chain networks and choose locations for facilities.
- To understand forecasting methods and how to plan supply and demand effectively.
- To learn how to manage uncertainty, maintain safety inventory, and coordinate activities in a supply chain.

Course Outcomes: After completion of this course, the students shall be able to:

1. Relate competitive and supply chain strategies
2. Identify drivers of supply chain performance
3. Analyze factors influencing network design.
4. Analyze the influence of forecasting in a supply chain
5. Evaluate the role of aggregate planning, inventory, IT and coordination in a supply

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1			1							1		
CO2	3	1			1							1		
CO3	3	2	2		2							1		1
CO4	3	2	2		1							1		1
CO5	2	2	2		2							1		1

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT- I

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

UNIT-II

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

UNIT III

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

UNIT IV

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC.

UNIT V

Managing uncertainty in a SC: Safety Inventory.
Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect

Suggested Reading:

1. Supply Chain Management - Strategy, Planning and Operation, Sunil Chopra and Peter Meindl, 6th Edition, Pearson Education Asia, 2016.
2. Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, 3rd Edition, TMH, 2008
3. Supply Chain Management – Text and Cases, Janat Shah, Second Edition, Pearson, 2016.
4. Supply Chain Metrics That Matter, Lora M. Cecere, Wiley, First Edition, 2015.

Course Code	Course Title						Course Type
PE847ME	**ENTREPRENEURSHIP**						**Professional Elective -IV**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation	Credits
	L	**T**	**D**	**P**		**CIE** / **SEE**	
	3	**-**	**-**	**-**	**3**	**40** / **60**	**3**

Course Objectives:

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation.
- To understand the behavioral aspects of entrepreneurs and time management

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Understand India's industries, small businesses, entrepreneurship, and their role in economic growth.
2. Understand who entrepreneurs are, how they find business ideas, and pick the right technology.
3. Learn to plan, analyze, and finance business projects effectively.
4. Learn to manage construction projects using planning tools like CPM/PERT, handle team dynamics, and assess taxes.
5. Understand entrepreneurial behavior, leadership, motivation, CSR, and effective time management techniques.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3		2							1		1	1	3
CO2			2							1		1	2	2
CO3	3				3					1		1	2	2
CO4	2		1		3					1		1	1	1
CO5					2					1		1	2	2

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Indian Industrial Environment – Competence; Opportunities and Challenges, Entrepreneurship and Economic growth, Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs, Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas, their sources and decision making. Choice of Technology – Collaborative interaction for Technology development.

UNIT-III

Project formulation, analysis of marked demand, demand supply gap, financial and profitability analysis, technical analysis and risk analysis. Project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM -PERT techniques. Humana aspects of project management. Assessment of tax burden.

UNIT-V

Behavioral aspects of entrepreneurs: Personality – determinats, attributes and models, leadership concepts and models. Values and attitudes. Motivation aspects, change behavior. Corporate social responsibility. Time Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Reading:

1. Vasant Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, 1997.
2. Prasanna Chandra, Project – Planning, Analysis, Selection, Implementation and Review||, Tata McGraw-Hill Publishing Company Ltd., 1995.
3. B. Badhai, Entrepreneurship for Engineers, Dhanpath Rai& Co., Delhi, 2001.
4. Stephen R. Covey and A. Roger Merrill, First Things First, Simon and Schuster, 2002.
5. Robert D. Hisrich and Michael P.Peters, Entrepreneurship, Tata McGRaw Hill Edition, 2002.

Course Code	Course Title						Course Type
MC801CE	**ENVIRONMENTAL SCIENCE**						**Mandatory Course**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	3	**-**	**-**	**-**	**3**	**40**	**60**	**-**

Course Objectives: The course is taught with the objectives of enabling the student to:

- Comprehend the need of environmental science, ethics and issues
- Realize the availability and utilization of various natural resources
- Illustrate the characteristics and functions of Ecosystem
- Study various environmental pollution effects, prevention and control acts
- Understand the concepts of Biodiversity and its conservation needs

Course Outcomes: On completion of this course, the student will be able to:

1. Application and awareness of various environmental issues for sustainable society
2. Acquaintance with utilization of various natural resources
3. Capacity to understand and practice for sustainability of ecosystem.
4. Knowledge of social and environment related issues and their preventive measures
5. Ability in conserving and protecting the biodiversity

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2		2		1	3	1	2	1		3	1	
CO2	3	2		2		1	3	2	1	1		3	1	
CO3	3	2		2		1	3	1	1	1		1	1	
CO4	3	2		2		1	3	1	1	1		3	1	
CO5	3	2		2		1	3	1	1	1		1	1	

Correlation rating: Low/Medium/High: 1/2/3 respectively

UNIT-I

Multidisciplinary nature of Environmental studies:

Definition, scope and importance, Need for public awareness, Environmental ethics: issues and possible solutions, Global Warming and Climate change, Acid rain, Ozone layer depletion. Environment and human health, Population growth, Sustainable development and SDGs

UNIT-II

Natural Resources:

Types of Natural Resources, Role of individual in conservation of natural resources, equitable use of resources for sustainable life styles, Natural resources and associated problems.

Land Resources: Land as a resource, land degradation, soil erosion and desertification.

Forest resources: Use and Overexploitation, Deforestation, Timber Extraction, Mining, Dams, and their Effects on Forests and Tribal People

Water resources: Water Resources: Use and Overutilization of Surface and Ground Water, Floods, Drought, Conflicts over Water, Dams – Benefits and problems

Mineral Resources: Use and Exploitation, Environmental Effects of Extracting and using Mineral Resources

Food Resources: World Food Problems, Changes Caused by Agriculture and Overgrazing, Effects of Modern Agriculture, Fertilizer-Pesticide Problems, Water Logging, Salinity, Energy Resources.

UNIT-III

Ecosystems:

Concept of an Ecosystem, Types, Structure and function of an ecosystem, Producers, consumers, decomposers. Energy flow in the ecosystems, Ecological succession, Food chains, food webs and ecological pyramids.

Introduction, types, characteristic features, structure and functions - Forest ecosystem, Grass land ecosystem, Desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

UNIT-IV

Environmental Pollution:

Definition, Causes, effects and control measures - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards,

Environmental Protection: Air (prevention and control of pollution) Act, Water (prevention and control of pollution) Act, Wildlife conservation and protection act, Forest conservation and protection act, Role of an individual's, communities and NGOs in prevention of pollution

Solid waste Management: Causes, effects and control measures of urban and industrial wastes

UNIT-V

Biodiversity and its Conservation:

Definition: genetics, species and ecosystem diversity, Spatial Patterns of Species Richness, Shannon's, Simpson's Diversity Index. Bio-geographically classification of India. Value of biodiversity - consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, national and local level. India as a mega diversity nation. Hot-spots of biodiversity,

Threats to biodiversity: habitats loss, poaching of wild life, man wildlife conflicts. Endangered and endemic spaces of India.

Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity, Biological Diversity Act, 2002.

Suggested Reading:

1. Erach Bharucha., Textbook of Environmental Studies, UGC, New Delhi and Bharathi Vidyapeeth Institute of Environment Education and Research, Pune.
2. MahuaBasu and Xavier Savarimuthu SJ., Fundamentals of Environmental Studies, Cambridge University Press, New Delhi, 2017.
3. Mishra D D., Fundamental Concepts in Environmental Studies, S Chand & Co Ltd., New Delhi, 2010.
4. Botkin and Keller., Environmental Science, Wiley India Pvt., Ltd., New Delhi, 2012.
5. Gilbert, M. Masters., Introduction to Environmental Engineering and Science, Prentice- Hall of India Pvt., Ltd., New Delhi, 1995.
6. Sasi Kumar, K. and Sanoop Gopi Krishna., Solid waste Management, Prentice-Hall of India Pvt., Ltd., New Delhi, 2009.
7. Daniel D. Chiras, Environmental Science, Jones & Bartlett Learning Publishers Inc, Burlington, MA, 2014.

Course Code	Course Title							Course Type
OC801ME	**Title as per the online course registration (SWAYAM-NPTEL)**							**MOOC-I**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
	-	**-**	**-**	**-**	**-**	**-**	**-**	**3**

Guidelines for MOOC (SWAYAM/NPTEL) Course Enrollment and Credit Transfer

1. Introduction

Massive Open Online Courses (MOOCs) offered through SWAYAM/NPTEL platforms provide students with flexible access to quality education. These courses allow learners to enhance their knowledge and earn academic credits as per university regulations.

2. Course Selection

- Students must select SWAYAM/NPTEL-MOOC courses as per the notifications issued by the University College of Engineering, Osmania University.
- The list of approved SWAYAM/NPTEL-MOOC courses, as endorsed by the Board of Studies (BoS) in Mechanical Engineering, will be updated periodically on the college website.
- Courses not on the approved list will not be eligible for credit transfer.

3. Enrollment Process

- Register (Enroll) for the selected course on the official SWAYAM/NPTEL portal.
- Submit enrollment confirmation to the designated SPOC (Single Point of Contact) Coordinator.
- Maintain proof of enrollment (screenshot/email confirmation).

4. Credit Structure

- ***As per SWAYAM-NPTEL guidelines, credits are assigned as follows:***
  - 4-week course → 1 credit
  - 8-week course → 2 credits
  - 12-week course → 3 credits
- ***To earn 3 credits, students may choose either:***
  - A single 12-week (3 credits) course, OR
  - A combination of a 4-week (1 credit) + 8-week (2 credits) course.

5. Examination & Certification

- Upon successful completion of the online course, students must appear for the online examination.
- Candidates who pass the exam will receive a certificate from SWAYAM/NPTEL.

6. Credit Transfer Process

- Submit original course certificate to the department
- The Board of Studies (BoS) Committee will evaluate the certificate authenticity to approve the credits.
- The Examination Cell will facilitate the credit transfer as per the academic regulations, and Credits reflected in academic records.

Important Notes

- Students must regularly check the college website for updates on approved courses.
- Students are responsible for tracking course deadlines and exam dates.
- No credit transfer will be processed without valid certification.
- Only courses completed during the study of B.E. (Mech. Engg.) program will be considered.
- For any queries, contact the SPOC Coordinator of the college.

Course Code	Course Title							Course Type
PW851ME	**PROJECT WORK - II**							**Core**
Prerequisite	Contact hours per week				Duration of SEE (Hours)	Scheme of Evaluation		Credits
	L	**T**	**D**	**P**		**CIE**	**SEE**	
Able to define Problem with specifications	**-**	**-**	**-**	**16**	**-**	**50**	**100**	**8**

Course Objectives:

- To enhance practical and professional skills.
- To familiarize tools and techniques of systematic Literature survey and documentation.
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas.

Course Outcomes:

1. Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to real-world problems.
2. Evaluate different solutions based on economic and technical feasibility.
3. Effectively plan a project and confidently perform all aspects of project management.
4. Demonstrate effective written and oral communication skills.

CO-PO Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1									3	1	1		1	
CO2					3				1		3		1	
CO3									1		3		1	
CO4					2				1	3				
CO5														

Correlation rating: Low/Medium/High: 1/2/3 respectively

Project Work Guidelines

Prerequisites:

- To undertake the project, the student must demonstrate the ability to:
- Define a **problem statement** with clear specifications.
- Conduct a **literature survey** (including familiarity with research journals).
- **Critically evaluate** existing techniques to address the problem.
- **Plan the work**, prepare graphs/bar (activity) charts, analyze results, and derive solutions.
- Present findings **scientifically** (both written and oral presentations).

Special Lecture Series

- **Conducted by:** Faculty members, research scholars, postgraduate students, and invited engineers from industries/R&D institutions.
- **Objective:** Introduce students to real-world technical challenges and problem-solving methodologies.

Seminar Schedule & Requirements

1. **Schedule**:
    a. Coordinated from the **5th week** to the end of the semester.
    b. **Strict adherence** is mandatory.
2. **Student Deliverables:**
    a. Submit a **one-page synopsis** (displayed on the notice board) prior to the seminar.
    b. Deliver a **20-minute presentation**, followed by a 10-minute discussion.
    c. Submit a **technical write-up** summarizing the talk.

3. **Evaluation:**
    a. **Two faculty members** will assess performance based on:
        i. Synopsis quality,
        ii. Presentation & discussion,
        iii. Technical write-up.
    b. **Sessional marks** will be awarded accordingly.