Autonomous Program Structure of
Final Year B. Tech. Eight Semester
(Mechanical Engineering)
Academic Year: 2023-2024 onwards

Course Code	Course Title	Teaching Scheme Hrs /Week			Examination Scheme				Total Marks	Credit
		Lecture	Tutorial	Practical	In Sem	End Sem	Practical	Oral		
20PEME801	Programme Elective – I*	3	0	0	50	50	0	0	100	3
20PEME802	Programme Elective - II	3	0	0	50	50	0	0	100	3
20PEME803	Programme Elective -III	3	0	0	50	50	0	0	100	3
20PEME804	Programme Elective -IV	3	0	0	50	50	0	0	100	3
20OE801	Open Elective III**	3	0	0	50	50	0	0	100	3
20OE802	Open Elective IV***	3	0	0	50	50	0	0	100	3
20PEME802L	Programme Elective – II Lab	0	0	2	25	0	0	25	50	1
	Total	**18**	**0**	**2**	**325**	**300**	**0**	**25**	**650**	**19**
	Grand Total	**20**			**625**		**25**			

*NPTEL / Swayam Course, **Open Elective-III: Department Level Course,***Open Elective-IV: Multi-disciplinary Course.

20PEME802 Programme Elective – II **20PEME802L Programme Elective – II Lab** A. Mechanics of Composite Materials B. Computational Fluid Dynamics C. Finite Element Method
20PEME803 Programme Elective - III A. Industrial Internet of Things B. Product Design and Development C. Data Science for Mechanical Engineering D. Design Thinking for Innovations
20PEME804 Programme Elective - IV A. Advanced Refrigeration and Air Conditioning B. Advance Solid Mechanics C. Optimization Techniques

20OE801 Open Elective-III			Eligible Departments				
Sr. No.	Course Code	Course Title	EnTC	Comp	IT	Mech	Instru
1	20OE801A	Big Data and Analytics	Y	Y	Y	Y	Y
2	20OE801B	Cyber Physical Systems	Y	Y	Y	N	Y
3	20OE801C	Digital Control	Y	N	N	Y	Y
4	20OE801D	Industrial Engineering and Management	Y	Y	Y	Y	Y
5	20OE801E	Introduction to Cyber-crime and Forensics	Y	Y	Y	Y	Y
6	20OE801F	Instrumentation in Food and Agriculture	Y	Y	Y	Y	Y
7	20OE801G	Medical IoT	Y	Y	Y	N	Y
8	20OE801H	Quantum Computing	Y	Y	Y	N	Y
9	20OE801I	Renewable Energy Sources	Y	Y	Y	Y	Y
10	20OE801J	Soft Computing	Y	Y	Y	Y	Y
11	20OE801K	Software Testing and Quality Assurance	Y	Y	Y	Y	Y

20OE802 Open Elective-IV			Eligible Departments				
Sr. No.	Course Code	Course Title	EnTC	Comp	IT	Mech	Instru
1	20OE802A	Applied statistics with R Programming	Y	N	N	Y	Y
2	20OE802B	Automobile Engineering	Y	Y	Y	N	Y
3	20OE802C	Autonomous Robots	N	Y	Y	Y	N
4	20OE802D	Building Automation and Energy Audit	Y	Y	Y	Y	N
5	20OE802E	Data Analysis and Visualization	Y	N	N	Y	Y
6	20OE802F	Data Science using Python	Y	N	N	Y	Y
7	20OE802G	Industrial Drives and Control	Y	Y	Y	Y	N
8	20OE802H	Smart Sensors and Structures	Y	Y	Y	Y	N
9	20OE802I	Wireless Networks	N	Y	Y	N	Y

Final Year B. Tech. -- Semester-II

Course Name	Programme Elective – II Mechanics of Composite Material	L	T	P
Course Code	20PEME802 A	3	-	-
Pre-requisite	Engineering Mechanics, Strength of Materials, Engineering Metallurgy			

Course Objectives: To make students

1. Understand a perspective utilization and processing of composite materials
2. Micro and macro mechanical analysis of the composite material at lamina level
3. Analyze the laminated composite material at macro level
4. Understand testing methods of composite materials to evaluate mechanical properties

Course Outcomes:

After successful completion of the course, student will be able to

1. Define need, utilization of class of composite material, its constitution and list its application fields
2. Demonstrate the various fabrication process of composite materials
3. Analyze lamina at micro-mechanical and macro-mechanical level of polymer matrix composites
4. Analyze laminated composites using classical lamination theory
5. Express testing method of evaluation of mechanical properties of polymer composites as per ASTM standard

Unit/Module: 1	Introduction to composite	6 hours	CO: 1

Introduction to advanced materials and types, Definition, General Characteristics, Applications, Fibers, Types of fibers, Mechanical Properties of fibers; Matrix, Types of matrix, Polymer Matrix- Thermoset and Thermoplastic, Fillers/Additives/Modifiers of Fiber Reinforced Composites

Unit/Module: 2	Manufacturing of composites	6 hours	CO: 2

fabrication process for thermoset and thermoplastic PMC, open mould process as hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, and Closed mould process as pultrusion, performing, thermo-forming, injection molding, blow molding, Process parameters.

Unit/Module: 3	Elastic and strength Behaviour of Lamina	9 hours	CO: 3

Micromechanical Analysis of Lamina: Introduction, Volume and mass fraction, density, void content, evaluation of elastic moduli, ultimate strength of unidirectional lamina

Macro-mechanical Analysis of Lamina: Review and definition of stress, strain and Elastic Moduli, Hooke's Law for different types of materials, Hook's law for 2D unidirectional and angular lamina, engineering constants of an angle lamina, Strength failure theories of an angle lamina

Unit/Module: 4	**Elastic Behavior of Laminate**	**9 hours**	**CO: 4**
Introduction to Laminate Code, Strain-displacement relations, Stress-strain relation for a laminate, force and moment resultants related to mid plane strains and curvatures, In-Plane engineering constants of a laminate, Flexural engineering constants of a laminate			
Unit/Module: 5	**Testing of Composites**	**6 hours**	**CO: 5**
Societies for Testing Standards, Background to Mechanical Testing of Composites, Test Method and analysis of Tensile Properties, Compressive Properties, Flexural Properties, In-Plane Shear Properties, Inter-laminar Shear Strength properties, Impact Properties.			
	Total Lab hours:	**36 hours**	

Text Books:

1.	Autar K. Kaw, "Mechanics of Composite Materials", CRC Press, Taylor & Francis Group, 2012.

Reference Books:

1.	Robert M. Jones, "Mechanics of Composite Materials" 2nd Edition, CRC Press 1998
2.	Isaac M. Daniels, Ori Ishai, "Engineering Mechaincs of Composite Materials", Oxford University Press, 2010
3.	Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press, 2004.

Course Name	Programme Elective – II Computational Fluid Dynamics	L	T	P
Course Code	PEME802 B	3	-	-
Prerequisites	Fluid dynamics, Heat transfer, Numerical methods	Syllabus Version		
		V:1.1		

Course Objectives: To make students

1. Finite volume method (FVM) of discretization for differential equations ,
2. Development of solution of discretized equations using various methods,
3. CFD tools to solve practical problems
4. Interpret CFD results of complex problems

Course Outcomes: Students will be able to

1. Discretize a given differential equation with FVM,
2. Write a simple codes for diffusion and convection problems,
3. Solve fluid flow and heat transfer problems with CFD tools
4. Apply CFD techniques to real life industrial problems.

Unit/Module: 1	Introduction to CFD	4 hours	CO: 1
What is CFD, Advantages of CFD, Applications: as a design and analysis tool, applications in aerospace, applications in automobile and EV, applications in bioscience etc.			
Unit/Module: 2	**CFD Fundamentals**	**6 hours**	**CO: 2**
Governing differential equations of fluid dynamics and heat transfer, RTT, continuity equation, Navier Stokes equations and energy equation, RANS, different types of boundary conditions.			
Unit/Module: 3	**CFD Procedure**	**8 hours**	**CO: 3**
Finite volume method, discretization of conduction and convection equations, various convective schemes, discretization of momentum equations, pressure velocity coupling, SIMPLE algorithm.			
Unit/Module: 4	**CFD Mesh Generation**	**6 hours**	**CO: 4**
Types of meshes, structuared, body-fitted and unstructured meshes, mesh refinement, moving meshes, mesh quality.			
Unit/Module: 5	**CFD Solution and Postprocessing**	**6 hours**	**CO: 5**
Convergence, residual and tolerance, consistency and stability, accuracy, sources of errors in solution, mesh independence study, verification and validation.			

Unit/Module: 6	**Applications with Examples**	**4 hours**	**CO: 6**
Lid driven cavity, pipe flow, flow over bends, heat transfer coupled with fluid flow, turbulent flow through a channel, flow over an aerofoil etc.			
	Total Lab hours:	**34 hours**	

Text Books:

1.	Jiyuan Tu, Guan-Heng Yeho and Chaoqun Liu, Fluid Dynamics: A Practical Approach, Elsevier.
2.	S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
3.	John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis
4.	Versteeg, H. K. and Malalasekara, W. (2008). Introduction to Computational Fluid Dynamics: The Finite Volume Method. Second Edition (Indian Reprint) Pearson Education.
5.	4. Anderson, J.D. Computational Fluid Dynamics, McGraw Hill, 1995.
6.	Ansys Fluent User's Guide, Ansys Inc.

Course Name	Programme Elective – II Finite Element Method	L	T	P
Course Code	20PEME802 C	3	-	-
Pre-requisite	Strength of Materials, Engineering Metallurgy, Heat Transfer			

Course Objectives:

To make students

1. To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics problems
2. To familiarize students with finite element method for displacement and stress analysis of 1D and 2D problems
3. To evaluate temperature distribution of heat transfer problem using FEM
4. To evaluate dynamic analysis problem using FEM

Course Outcomes:

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

1. Understand the different FEM techniques used to solve mechanical engineering problems.
2. Derive and apply element stiffness matrices and load vectors to solve beam and rigid frame problems
3. Derive and apply isoparametric elements and numerical integration to solve plane stress problems
4. Apply 1D heat transfer FEM formulation to solve for temperature distribution
5. Evaluate dynamic analysis of beam using FEM formulation

Unit/Module: 1	Introduction to Finite Element Method	6 hours	CO: 1

General description and engineering applications of finite element method, Boundary conditions: homogeneous and nonhomogeneous for structural, heat transfer and fluid flow problems.
Different approaches: Potential energy method, Rayleigh-Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process.
Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes.
Types of Analysis: Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.

Unit/Module: 2	Analysis of Beams and Rigid Frames	8 hours	CO: 2

Introduction, Beam Analysis Using two Noded Elements, Analysis of Rigid Plane Frame Using 2 Noded Beam Elements, Timoshenko Beam Element: Formulation, element stiffness matrix, assemblage stiffness matrix and solve for static load

Unit/Module: 3	**Analysis of Plane stress with isoparametric elements and numerical integration**	**8 hours**	**CO: 3**
Concept of isoperimetric elements, Terms isoperimetric, super parametric, and sub parametric. Coordinate mapping: Natural coordinates, Area coordinates (for triangular elements), higher-order triangular and quadrilateral elements, geometry associative mesh, quality checks, mesh refinement- p vs h refinements, Uniqueness of mapping – Jacobian matrix. Numerical integration: Gauss Quadrature in one and two dimensions, Order of Gauss integration, full and reduced integration, sub-modelling, sub structuring.			
Unit/Module: 4	**Steady-State Heat Transfer**	**6 hours**	**CO: 4**
Introduction, One-dimensional steady-state heat transfer problem- Governing differential equation, Finite Element formulation using Galerkin's approach for composite wall and thin fin, essential and natural boundary conditions and solving for temperature distribution			
Unit/Module: 5	**Dynamic Analysis**	**8 hours**	**CO: 5**
Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element. Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors.			
	Total hours:	**36 hours**	

Text Books:

1.	Daryl Logan, First Course in the Finite Element Method, Cengage Learning India Pvt. Ltd.
2.	S.S. Bhavikatti, Finite Element Analysis, New Age International (P) Ltd, 2005

Reference Books:

1.	R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India
2.	Reddy J.N., An Introduction to Finite Element Method, 3rd ed., Tata McGraw Hill, 2005.
3.	G Lakshmi Narasaiah, Finite Element Analysis, BS Publications, 2008.
4.	Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
5.	P., Seshu, Textbook of Finite Element Analysis, PHI Learning Private Ltd. , New Delhi, 2010.

Course Name	Programme Elective – III Industrial Internet of Things	L	T	P
Course Code	20PEME803 A	3	-	-
Pre-requisite	Engineering fundamentals and principles	Syllabus Version		
		V:1.1		

Course Objectives:

To make students

1. Understand protocol, prototype of IoT based smart system
2. Understand Automatic Storage Management.
3. Understand Internet of Things-Ethics and Governance.
4. Understand Smart Manufacturing techniques, smart design, and fabrication Smart application.

Course Outcomes:

Students will be able to

After successful completion of the course, student will be able to

1. Apply protocol and prototype concepts for IIOT.
2. Justify the role of Automatic storage Management in IIOT
3. Follow ethical practices while developing IIOT applications
4. Design Smart manufacturing and Fabrication applications.

Unit/Module: 1	The Internet of Things, Thinking about Prototyping, Prototyping Embedded devices	6 hours	CO: 1

1**The Internet of Things**: **Protocols and Prototyping, Prototyping Embedded devices** An overview; Design Principles for Connected Devices, Internet Principles– Electronics, Embedded Computing Basics, Arduino/Raspberry Pi/ BeagleBone Black/ etc. Prototyping online Components – Getting Started with an API, Writing a New API(Application programming interface)

Unit/Module: 2	Automatic Storage Management	6 hours	CO: 2

Real Time Reactions and Automatic Storage Management, Other Protocols. Techniques for Writing Embedded Code – Memory Management, Performance. Automatic Storage Management in a Cloud World – Introduction to Cloud, Relational Databases in the Cloud, Automatic Storage Management in the Cloud.Smart Connected System Design Case Study.

Unit/Module: 3	Internet of Things-Ethics, Privacy, Security and Governance	4 hours	CO: 3

Introduction, Ethics Overview of Governance, Privacy and Security Issues,

Unit/Module: 4	Introduction to Smart Manufacturing	8 hours	CO: 4

Smart manufacturing, Smart Manufacturing Processes- Three Dimensions: (1) Demand Driven and Integrated Supply Chains;(2) Dynamically Optimized Manufacturing Enterprises (plant + enterprise

operations);(3) Real Time, Sustainable Resource Management (intelligent energy demand management, production energy optimization and reduction of GHG)			
Unit/Module: 5	**Smart Design/Fabrication, Smart Applications, Tools for IIOT**	**8 hours**	**CO: 4**
Smart Design/Fabrication - Digital Tools, Manufacturing Systems and Standards. Smart Applications Case study			
	Total Lab hours:	**32 hours**	

Text Books:	
1.	Designing the Internet of Things by Adrian McEwen and Hakim Cassimally
2.	Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud by Cuno Pfister
3.	Foundational Elements of an IOT Solution - The Edge, Cloud and Application Development, Joe Biron& Jonathan Follett, Oreilly, First Edition, March 2016
4.	The Internet of Things (A Look at Real World Use Cases and Concerns), Kindle Edition, 2016, Lucas Darnell
5	Designing Connected Products, 1st Edition, Elizabeth Goodman, Alfred Lui, Martin Charlier, Ann Light, Claire Rowland
6	Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1 stEdition, VPT, 2014. (ISBN: 978-8173719547)

Course Name	Programme Elective – III Product Design and Development	L	T	P
Course Code	20PEME803 B	3	-	-
Pre-requisite	Manufacturing Processes, Industrial Inspection, Quality Control, Machin Design	Syllabus Version		
		V:1.1		

Course Objectives:

Course prepares students to

1. Understand to Product Design Process and Product Policy.
2. Learn the fundamental of Product Design Morphology Tools.
3. Understand Design for Manufacturing and Assembly.
4. Learn Design for Environment, Quality and IPR.

Course Outcomes:

Students will be able to

1. Analyse to identify different phases of product design and Product life-cycle,
2. Apply product design morphology tools to analyse requirements/functionality,
3. Apply techniques of Design for Manufacturing and Assembly for product design,
4. Identify factors while designing for Environment w.r.to manufacturing reusability, standards

Unit/Module: 1	Introduction to Product Design Process and Product Policy	6 hours	CO: 1

- Introduction to product design: Product design process, Product life-cycle,
- Product policy of an organization. Selection of a Profitable product, Product design process, Product analysis,
- System engineering in product design: Boundary Diagram and P-Diagram.

Unit/Module: 2	Product Design Morphology Tools	6 hours	CO: 1

- Problem identification and selection, Product Characteristics, KJ Model, DFMEA,
- Analysis of functions, and Anatomy of function: Primary versus secondary versus tertiary/unnecessary functions, Functional analysis: Functional Analysis System Technique (FAST),
- Visual Design, and Quality Function Deployment (QFD),
- Value engineering in product design; Advantages, Applications in product design,
- Ergonomics in product design, Case studies.

Unit/Module: 3	Material and Manufacturing Process Selection	8 hours	CO: 2

- DFX and DFMA during product design: Advantages and case studies,
- Classification and Selection: Introduction to Manufacturing processes,
- Introduction to selection of Manufacturing processes and materials for product design.

Unit/Module: 4	Product Design for Assembly and Maintenance	6 hours	CO: 3

- Design for Assembly: The assembly process, Characteristics and applications, General taxonomies of assembly operation and systems, Examples of common assemblies;
- DFA for design consideration and design recommendation for Part Handling- Insertion, Fasteners [e.g. for manual assembly, high-speed automatic assembly and robot assembly],
- DFA analysis (evaluating assembly): Assembly Metrics, DFA index, Example of worksheet.

Unit/Module: 5	Product Design for Manufacturing	5 hours	CO: 3

- Design for Marching: Turning, Milling, Round-Holes Machining, Grinding etc.
- Design for Forming and Joining Processes: Design for Castings, Injection Molding, Forging, Sheet-metal stamping Welding Extrusion and Powder Metal Processing
- Product design for Rapid Prototyping:, Needs, Advantages, Working Principle
  - [Process steps, typical characteristics and applications; Defects; Suitable materials; Dimensional factors and tolerances Design consideration and recommendations for selected process],

Unit/Module: 6	Design for Environment, Quality and IPR	3 hours	CO: 4

- Product design for Environment (w.r.to Standards / Norms),
- Product design for Quality Control (Inspection requirements w.r.to GD&T),
- Introduction to Reverse Engineering and Frugal Technology,
- Product design and IPR.

	Total Lecture hours:	**36 hours**	

Text Books:

4.	Eppinger, S. and Ulrich, K., 2015. Product design and development. McGraw-Hill Higher Education
5.	Magrab, E.B., Gupta, S.K., McCluskey, F.P. and Sandborn, P., 2009. Integrated product and process design and development: the product realization process. CRC Press.
6.	Boothroyd, G., 1994. Product design for manufacture and assembly. Computer-Aided Design, 26(7), pp505-520.

Reference Books:

1.	G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press.
2.	K. T. Ulrich and S. D. Eppinger, Product Design and Development, McGraw-Hill Higher Education.
3.	Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill.

4.	G E Dieter, Engineering Design - A Material Processing Approach, McGraw Hill.
5.	B. R. Fischer, Mechanical Tolerance stackup and analysis, CRC Press.

Course Name	Programme Elective - III Data Science for Mechanical Engineering	L	T	P
Course Code	20PEME803 C	3	-	-
Pre-requisite	Engineering fundamentals and principles	Syllabus Version		
		V:1.1		

Course Objectives:

To make students

1. Relevance of data science in mechanical engineering
2. Mathematics and statistical fundamentals for data science
3. Machine learning and AI software frameworks
4. Current trends in mechanical engineering using data science

Course Outcomes:

Students will be able to

1. Solve data driven problems
2. Use ML software frameworks
3. Apply reinforcement learning to robotic problems
4. Undertake research problem in mechanical engineering that involves data science concepts

Unit/Module: 1		6 hours	CO: 1
Mathematical and statistical foundations of data science			
Unit/Module: 2		**4 hours**	**CO: 2**
Introduction to data science, machine learning, and Artificial Intelligence			
Unit/Module: 3		**6 hours**	**CO: 3**
Foundations of Python programming for data science, numpy, pandas, OpenCV, matplotlib etc.			
Unit/Module: 4		**8 hours**	**CO: 4**
Introduction to Neural Networks and Deep Learning: Theoretical concepts, ML frameworks such as Tensorflow, PyTorch			
Unit/Module: 5		**6 hours**	**CO: 5**
Reinforcement learning: Applications of RL in Robotics, OpenAI Gym for RL environment			
Unit/Module: 6		**4 hours**	**CO: 6**
Applications and case studies: Recent research in solid mechanics, fluid dynamics and robotics in			

context of data science			
	Total Lab hours:	**32 hours**	

Text Books:

1.	Andreas Müller, Introduction to Machine Learning with Python: A Guide for Data Scientists, O'Relly Media
2.	Laura Igual, Introduction to Data Science, Springer
3.	Gareth James, Introduction to Statistical learning, Springer, 2017
4.	www.tensorflow.org, www.pytorch.org, www.openai.com, www.python.org

Course Name	**Programme Elective - III** **Design Thinking for Innovations**	**L**	**T**	**P**
Course Code	**20PEME803 D**	**3**	**-**	**-**
Pre-requisite	Engineering fundamentals and principles	**Syllabus Version**		
		V:1.1		

Course Objectives: To make students

1. Principles of innovative mindset
2. Methods and techniques to define customer needs
3. Generate a pool of ideas and solutions
4. Seek solutions to real life problems though innovations

Course Outcomes: Students will be able to

1. Identify needs and problems for innovations
2. Create ideas and find alternate solutions
3. Implement ideas and create prototypes
4. Apply design thinking principle to real life problems

Unit/Module: 1	**Principles of design thinking**	**4 hours**	**CO: 1**
Empathise, define, ideate, prototype and test			
Unit/Module: 2		**6 hours**	**CO: 2**
Need identification and problem definition			
Unit/Module: 3		**6 hours**	**CO: 3**
Ideation and brainstorming			
Unit/Module: 4		**4 hours**	**CO: 4**
Implementation, Prototyping and testing of ideas			
Unit/Module: 5		**4 hours**	**CO: 5**
Applications and examples of Design Thinking			
Unit/Module: 6	**Design Thinking case studies**	**6 hours**	**CO: 6**
business, manufacturing, service industries and public services.			
	Total Lab hours:	**30 hours**	

Text Books:	
1.	Christian Muller-Rotenberg, Design Thinking for Dummies, Wiley 2020
2.	Design Thinking Toolkit, Ideo.org
3.	Harry Plattner, Christopher Meinel, Larry Leifer, Design Thinking, Springer
4.	Jeane Liedtka, Solving Problems with Design Thinking, Columbia Uni. Press, 2013

Course Name	**Programme Elective – IV** **Advanced Refrigeration and Air Conditioning**	**L**	**T**	**P**
Course Code	**20PEME804_A**	**3**	**-**	**-**
Prerequisite	1. Heat Transfer 2. Fluid Mechanics 3. Applied Thermodynamics	**Syllabus Version**		
		V:1.1		

Course Objectives: To make students

1. Select appropriate refrigerant for the given application analyze refrigeration cycles and understand heat driven refrigeration systems
2. Analyze refrigeration cycles and understand heat driven refrigeration systems.
3. Estimate cooling load for air conditioning systems.
4. Analyze various air conditioning systems.
5. Analyze duct systems for air distribution.
6. Appraise energy performance of the buildings

Course Outcomes: Students will be able to

1. Select appropriate refrigerant for the given application analyze refrigeration cycles and understand heat driven refrigeration systems
2. Analyze refrigeration cycles and understand heat driven refrigeration systems.
3. Estimate cooling load for air conditioning systems.
4. Analyze various air conditioning systems.
5. Analyze duct systems for air distribution.
6. Appraise energy performance of the buildings

Unit/Module: 1	**Refrigerants**	**3 hours**	**CO: 1**

Classification of refrigerants, designation of refrigerants, desirable properties of refrigerants, environmental issues, selection of environment friendly refrigerants, alternative refrigerants

Unit/Module: 2	**Vapor Refrigeration Cycles**	**6 hours**	**CO: 2**

Advanced vapor compression cycles – Trans critical cycle, Ejector refrigeration cycle

Vapor absorption systems- Aqua ammonia system, Electrolux refrigerator

Unit/Module: 3	Air Conditioning Load Estimation	**15 hours**	**CO: 3**

Refrigeration and Air Conditioning System Components: –
Compressors- Reciprocating, centrifugal, screw, scroll, inverter based
Evaporators
Condensers- Shell and Tube type , evaporative condenser
Expansion Devices- Capillary tube, Thermostatic Expansion valve, Electronic Expansion valve

Cooling Towers
Air cooling v/s Air Conditioning, Review of psychrometric processes, Thermodynamic of human body
Factors impacting heating/cooling load
Concept of infiltration, ventilation, indoor air quality requirements, solar radiation
Cooling Load Temperature Difference method
Overview of energy codes – ECBC, Eco Niwas Samhita, IECC
Overview of Energy Simulation Softwares

Unit/Module: 4	**Advanced Air Conditioning systems**	**6 hours**	**CO: 4**
Desiccant air conditioning systems, evaporative cooling, thermal energy storage air conditioning systems, radiant cooling heat pump systems, Under floor air delivery systems Selection Criteria			
Unit/Module: 5	**Air Distribution System**	**6 hours**	**CO: 5**
Ducts - Air flow through simple duct system. Pressure losses in duct Method of duct system design- equal friction, velocity reduction method, static regain method Air handling unit- Fan coil unit, filters, supply and return grills			
Unit/Module: 6	**Building Energy Efficiency**	**3 hours**	**CO:6**
Introduction to high performance buildings, building controls and building management system, commissioning and audits of building systems, Green building rating systems			
	Total course hours:	**hours**	**39**

Text Books:

1.	Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill
2.	Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd
3.	McQuiston, Heating Ventilating and air Conditioning: Analysis and Design, Wiley India
4.	Arora and Domkundwar, Refrigeration & Air Conditioning, Dhanpat Rai & Company, New Delhi
5.	ASHRAE Handbooks
6	Threlkeld J.L., Thermal Environmental Engineering, Prentice Hall Inc. New Delhi
7	Shan Wang, Handbook of Refrigeration and Air Conditioning, McGraw Hill Publications

Course Name	**Programme Elective – IV** **Advanced Solid Mechanics**	**L**	**T**	**P**
Course Code	**20PEME804_B**	**3**	**0**	**0**
Pre-requisites	Basics of Engineering Mechanics and Strength of Materials	**Syllabus Version**		
		V:1.1		

Course Objectives: To make students

1. Understand the concept of tensor.
2. Analyse advanced concept of stress and strain in structural problems.
3. Apply the concept of different elastic functions to solve complex problems.
4. Evaluate the influence of various geometric and loading parameters in plane stress and plane strain problems.
5. Implement advanced concept of solid mechanics in torsion, plates and shells

Course Outcomes : Students will be able to

1. Understand the concept of tensor.
2. Analyse advanced concept of stress and strain in structural problems.
3. Apply the concept of different elastic functions to solve complex problems.
4. Evaluate the influence of various geometric and loading parameters in plane stress and plane strain problems.
5. Implement advanced concept of solid mechanics in torsion, plates and shells

Unit :1	Mathematical Preliminaries:	7 hours	CO: 1

Introduction to tensor algebra: symmetric and skew-symmetric tensor, summation convention, eigenvalue and eigenvector of tensor, spectral theorem, polar decomposition theorem, product of tensor, principal invariants of tensor, coordinate transformation of tensor, Tensor calculus: gradient, divergence, curl, differentiation of scalar function of a tensor.

Unit : 2	Analysis of Stress and Strain:	8 hours	CO: 2

Definition and notation of stress, Cauchy stress tensor, equations of equilibrium, principal stresses and stress invariants, stress deviator tensor, octahedral stress components, General deformations, small deformation theory, strain transformation, principal strains, spherical and deviatoric strains, Strain-displacement relations, strain compatibility, stress and strain in curvilinear, cylindrical, and spherical coordinates, fundamental equations of plasticity.

Unit : 3	Problem formulation and solution strategies:	7 hours	CO: 3
Field equations, boundary conditions, stress and displacement formulation, Beltrami-Michell compatibility equations, Lame-Navier's equations, principle of superposition, uniqueness theorem, Saint-Venant's principle, Brief descriptions about general solution strategies - direct, inverse, semi-inverse, analytical, approximate, and numerical methods.			
Unit : 4	**Two-dimensional problems:**	**7 hours**	**CO: 4**
Plane stress and plane strain problems, generalized plane stress, Antiplane strain, Airy stress function, polar coordinate formulation and solutions, Cartesian coordinate solutions using polynomials and Fourier series method.			
Unit : 5	**Applications:**	**7 hours**	**CO: 5**
Torsion of noncircular shafts: Warping and Prandtl stress function, Torsion analysis of circular, elliptical, and rectangular cylinder using Warping and Prandtl function, Membrane analogy, Photo elasticity, Plates and shells – Fundamental equations, Kirchhoff's theory, axisymmetric bending of circular plates, membrane theory of shells of revolutions.			
	Total Theory Lecture hours:	**35 hours**	

Text Books:

1.	Elasticity, Theory, Applications, and Numerics by Martin H. Sadd
2.	Theory of Elasticity by Stephen Timoshenko and , J. N. Goodier
3.	Advanced Mechanics of Solids, Otto T. Bruhns, Springer publications.

Reference Books:

1.	Continuum Mechanics, A.J.M Spencer, Dover Publications, INC
2	Advanced Mechanics of Materials by H. Ford and J. M. Alexander
3	The Linearized Theory of Elasticity, W. S. Slaughter, Springer Science+Business Media, LLC

Course Name	Programme Elective – IV Optimization Techniques	L	T	P
Course Code	20PEME804 C	3	-	-
Prerequisite	Engineering Mathematics	Syllabus Version		
		V:1.1		

Course Objectives:

1 To introduce to the students optimization problems and various solution techniques ,

2 To impart knowledge of various classical and modern optimization techniques

3 To make students aware about industrial optimization problems

4 To expose students to numerical techniques to solve optimization problems

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

1 formulate objective functions and constraint equations for a given classical problem,

2 apply classical and modern method of optimization to standard problems

3 solve realistic and industrial design problems

4 use computational tools such as MATLAB/OCTAVE to get solutions

Unit/Module: 1	Introduction to Optimization	4 hours	CO: 1

Engineering Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Graphical Optimization Techniques.

Unit/Module: 2	Classical Optimization Techniques	6 hours	CO: 2

Single-Variable Optimization, Multivariable Optimization with No Constraints, Multivariable Optimization with Equality Constraints: Solution by Direct Substitution, Solution by the Method of Constrained Variation, Solution by the Method of Lagrange Multipliers, Multivariable Optimization with Inequality Constraints: Kuhn–Tucker Conditions, Constraint Qualification, Convex Programming Problems.

Unit/Module: 3	Linear Programming: Simplex Method	4 hours	CO: 3

Applications of Linear Programming,Standard Form of a Linear Programming Problem, Simplex Algorithm, Two Phases of the Simplex Method

Unit/Module: 4	**Nonlinear Programming**	**6 hours**	**CO: 4**
Introduction, Unrestricted Search, Interval Halving Method, Golden Section Method, Quadratic Interpolation Method, Newton's Method, Practical Considerations			
Unit/Module: 5	**Intro to Special Optimization Methods**	**6 hours**	**CO: 5**
Dynamic Programming, Optimal Control			
Unit/Module: 6	**Modern Methods of Optimization**	**6 hours**	**CO: 6**
Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, Neural-Network-Based Optimization, Practical Aspects of Optimization			
	Total Lab hours:	**32 hours**	
Text Books:			
1.	Engineering Optimization -Theory and Practice/ Singerusu S. Rao/ New Age.		
2.	Optimum Design of Mechanical elements/ Johnson Ray C/ Wiley, John & Sons		
3.	Optimization for Engineering Design Algorithms and Examples/ Kalyanamoy Deb/Prentice Hall of India		

Course Name	Programme Elective – II Lab Mechanics of Composite Material Lab	L	T	P
Course Code	20PEME802L_A	-	-	2
Pre-requisite	Engineering Mechanics, Strength of Materials, Engineering Metallurgy			

Course Objectives:

To make students

1. Micro and macro mechanical analysis of the composite material at lamina level
2. Analyze the laminated composite material at macro level
3. Manufacture the unidirectional laminated composite material
4. Test composite materials to evaluate mechanical properties

Course Outcomes:

After successful completion of the course, student will be able to

1. Analyze lamina at micro-mechanical and macro-mechanical level of polymer matrix composites
2. Analyze laminated composites using classical lamination theory
3. Fabricate the unidirectional composite laminate using compression molding process
4. Test and evaluate mechanical properties of polymer composites as per ASTM standards

Lab Work:

1. Develop a program for micro mechanical analysis of composite lamina
2. Develop a program for macro mechanical analysis of composite lamina and laminate
3. Develop a program for failure analysis of composite laminate using different failure theories.
4. Manufacturing of unidirectional and multidirectional fiber reinforced polymer matrix composites
5. Tensile testing of composite lamina to find out tensile strength and tensile modulus
6. Flexural testing of composite lamina to find out flexural strength and flexural modulus
7. Izod/Charpy impact test of composite lamina to find out impact strength

Text Books:

1. P K Mallik, "Fibrer Reinforced Composites: Materials, Manufacturing and Design", CRC Press, Taylor & Francis Group, Third Edition 2015.

Course Name	Programme Elective – II Lab Computational Fluid Dynamics Lab	L	T	P
Course Code	20PEME802 L_B	-	-	2
Prerequisites	Fluid Dynamics, HT, CFD	Syllabus Version		
		V:1.1		

Course Objectives: Introduce students to

1. To develop simple FVM codes
2. To set up and solve fluid flow and HT problems with CFD tools
3. To carry out simulations of real life CFD problems

Course Outcomes:

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

1. Develop simple FVM codes
2. Use CFD tools
3. Simulate CFD problems and postprocess the results.
4. Interpret CFD results and draw scientific conclusions

Lab Work:

1. Finite Volume Method code for two-dimensional conduction problem.
2. FVM code for convection problem.
3. Demonstration and study of NSE Solver
4. Lid driven cavity problem using Ansys Fluent
5. Flow through a channel: Fluent tutorial
6. Flow over airfoil: Fluent tutorial
7. 2-D heat transfer problems in Fluent
8. Simple turbulent flow simulations in Fluent

Text Books/References:

1. ANSYS user guide https://www.ansys.com/academic/learning-resources

Course Name	Programme Elective – II Lab Finite Element Method Lab	L	T	P
Course Code	20PEME802L_C	-	-	2
Pre-requisite	Strength of Materials, Engineering Metallurgy, Heat Transfer			

Course Objectives:

1. To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics problems
2. To familiarize students with finite element method for displacement and stress analysis of 1D and 2D problems
3. To evaluate temperature distribution of heat transfer problem in FEM
4. To evaluate natural frequency through dynamic analysis of mechanical component

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

1. Understand the different FEM techniques used to solve mechanical engineering problems.
2. Derive and apply beam and rigid frame element stiffness matrices and load vectors to solve for displacements and stresses.
3. Derive and apply isoparametric formulation of element stiffness matrices and load vectors to solve plane stress problems for displacements and stresses.
4. Apply 1D heat transfer FEM formulation to solve for temperature distribution

Lab Work:

1. A computer program for stress analysis of beam using linear and quadratic elements
2. A computer program for stress analysis of rigid frame using FEM formulation
3. A computer program for stress analysis of plane stress using the isoparametric formulation
4. A computer program for 1-D temperature analysis for heat transfer problem
5. Static stress concentration factor calculation for a plate with center hole using FEA software
6. Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software.
7. Modal analysis of any machine component using FEA software.
8. Temperature distribution analysis of Steady-state heat transfer problem using FEA software

Text Books/References:

1. Nitin S. Gokhale, Practical Finite Element Analysis, Finite to Infinite; First edition
2. ANSYS user guide https://www.ansys.com/academic/learning-resources