

SEMESTER 5

MECHANICAL ENGINEERING

SEMESTER S5

DYNAMICS OF MACHINERY

Course Code	PCMET501	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3: 1: 0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Mechanics of Machinery (PBMET404)	Course Type	Theory

Course Objectives:

1. To understand the rigid- body dynamics of kinematically driven machine components and perform the force analysis
2. To understand the gyroscopic effect on stability of road vehicles, aeroplanes, ships; devise methods to control the fluctuation of power and speed of IC engines, perform balancing of masses to reduce vibrations in machines
3. To understand the theory of vibrations and perform analysis of single degree of freedom (SDOF) systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Static Force analysis: Static equilibrium conditions, Two & three force members, four bar and slider crank mechanisms (graphical and analytical), method of virtual work. Dynamic force analysis: Force & moment equilibrium, Inertial forces, D' Alembert's principle. Dynamic analysis of four-bar and slider-crank mechanisms.	11
2	Gyroscope - effect of gyroscopic couple on - bearings, the stability of - two wheel, four wheel vehicles, ships and aircrafts. Balancing of rotating masses- single mass, several masses in same and in different planes; Balancing of reciprocating masses, partial balancing of	11

	single cylinder and multi-cylinder inline engines	
3	Flywheels- turning moment diagrams-for four stroke IC engines; Coefficient of fluctuation of energy, speed; energy stored in a flywheel, design of flywheels, applications. Governor Mechanisms- types of governors, gravity controlled -Watt, Porter and Proell governors, Spring controlled- Hartnell governor; Isochronism, sensitivity, stability and hunting.	11
4	Vibration Analysis: Undamped free vibrations of SDOF systems - natural frequency of longitudinal, transverse and torsional vibrations by Newton's method and energy method; Damped systems and critical damping, logarithmic decrement. Forced harmonic vibration, response of reciprocating and rotating unbalance, magnification factor, resonance; whirling of rotating shafts, vibration isolation and transmissibility, accelerometer.	11

**Course Assessment Method
(CIE: 40marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p align="center">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p align="center">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Perform the force analysis of four bar kinematic systems.	K2, K3, K4
CO2	Perform balancing of rotating and reciprocating masses in machines; understand the function and determine the gyroscopic effect on stability of automobiles, ships and aeroplanes.	K2, K3
CO3	Understand the principle of governors/ flywheel for the control of speed/energy fluctuation in engines or machines, and perform its analysis and design.	K2, K3
CO4	To determine the natural frequencies, perform the analysis of free or harmonically excited vibration response of damped and undamped vibratory SDOF systems	K2, K3, K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	-	-	-	-	-	2	-	-	3
CO2	3	2	3	-	-	-	-	-	2	-	-	3
CO3	3	2	3	-	-	2	-	-	2	-	-	3
CO4	3	2	3	-	3	2	-	-	2	-	-	3

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Theory of Machines	S. S. Rattan	Tata McGraw-Hill Education	4th edition, 2017
2	Theory of Machines and Mechanisms	Ballaney P. L.	Khanna Publishers	21st edition, 2020
3	Theory of Machines	Thomas Bevan	Pearson Education Ltd.	3rd Edition, 2010
4	Textbook of Mechanical Vibrations	Dukkipati R.V., J Srinivas	Prentice Hall India	2nd Edition, 2012

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Theory of Mechanisms and Machines	Amithabha Ghosh, Asok Kumar Malik	East West Press	2011
2	Kinematics and dynamics of machinery	Robert L Norton	McGraw-Hill Education	1st edition in SI units 2009
3	Kinematics and Dynamics of Machinery	Charles E. Wilson, J. Peter Sadler	Pearson Education Ltd.	3rd Edition, 2008
4	Theory of Machines and Mechanisms	John J. Uicker, Gordon R. Pennock, Joseph E. Shigley	Oxford University Press	5th edition, 2017
5	Theory of vibration with applications	W. T Thomson	CBS Publishers	1st Indian edition, 1990
6	Mechanical vibrations and Industrial noise control	Lasithan L G	PHI Learning	1st edition, 2014

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/104/112104114/ (Dynamics of Machines, by Prof. Amitabha Ghosh, IIT Kanpur)
2	https://archive.nptel.ac.in/courses/112/104/112104114/
3	https://archive.nptel.ac.in/courses/112/104/112104114/
4	https://archive.nptel.ac.in/courses/112/107/112107212/ https://www.youtube.com/watch?v=9t9qZMhnRFE https://www.youtube.com/watch?v=R7pF2WC4hXQ

SEMESTER 5

ADVANCED MANUFACTURING ENGINEERING

Course Code	PCMET502	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Manufacturing Processes (PBMET304), Machine Tools and Metrology (PCMET402)	Course Type	Theory

Course Objectives:

1. Learn how to program CNC machines and control automated equipment with PLC.
2. To introduce machining principles and processes in the manufacturing of precision components and products that use non-conventional technologies.
3. To offer a basic understanding of machining capabilities, limitations, and productivity of advanced manufacturing techniques.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>CNC: systems – Principle of operation, components of CNC system, coordinate systems, classification of CNC systems, point-to-point and contouring systems, incremental and absolute programming methods, open loop and closed loop systems, feedback devices.</p> <p>Interpolators: liner, circular and complete interpolator.</p> <p>Manual part programming - Computer aided part programming - APT. Programming exercises in turning, drilling and milling operations.</p> <p><i>(At least one programming exercise must be included in the end-semester</i></p>	11

	<i>examination).</i>	
2	<p>Programmable Logic Controllers (PLC) – input and output devices, ladder logic programming, simple problems only.</p> <p>Advanced Machining Processes: ultrasonic machining (USM), Abrasive jet machining (AJM), Water jet machining (WJM), Abrasive water jet machining (AWJM), Electrochemical machining (ECM), Electro discharge machining (EDM), Electron beam machining (EBM), Laser beam machining (LBM), Plasma arc machining (PAM), Ion beam machining (IBM).</p>	11
3	<p>Advanced Metal Forming Processes: High velocity forming of metals - Sheet metal forming - explosive forming - Electro hydraulic forming - Electro Magnetic Forming.</p> <p>Stress waves and deformation in solids – types of elastic body waves- relation at free boundaries- relative particle velocity.</p> <p>Microfabrication process: CVD, PVD, LIGA process.</p> <p>Micromachining: Diamond turn mechanism.</p>	11
4	<p>Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. - Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining.</p> <p>Material addition processes: - stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser-engineered net-shaping.</p>	11

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p align="center">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub-divisions. <p align="center">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	CNC programming, select appropriate tooling and parameters.	K3
CO2	To categorize the various non -traditional material removal processes based on energy sources and mechanisms employed.	K2
CO3	Analyze the processes and evaluate the role of each process parameter during the micromachining of various advanced material removal processes.	K3
CO4	Explain the processes used in additive manufacturing for a range of materials and applications.	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2		2	-	-	-	-	-	-	2
CO2	3	-	-	-	2	-	-	-	-	-	-	2
CO3	3	-	-	-	2	-	-	-	-	-	-	2
CO4	3	-	-	-	2	-	-	-	-	-	-	2

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Computer control of manufacturing systems	Yoram Koren	TMH	2017
2	Advanced Machining Processes	Jain V.K.	Narosa publishers	2014
3	Introduction to Micromachining	Jain V.K.	Narosa publishers	2014
4	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing	Ian Gibson, David Rosen, Brent Stucker	Springer Nature	2nd ed. 2015

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Computer-Aided Design and Manufacturing	M.P. Groover, E.M. Zimmers, Jr.	Prentice Hall of India	1987
2	Programmable logic controllers	PetruzellaFrank.D.	McGraw Hill	2016
3	Developments in high-speed metal forming	Davies K and Austin E.R	The Machinery Publishing Co	1970

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://nptel.ac.in/courses/112105211
2	https://nptel.ac.in/courses/112104028
3	https://nptel.ac.in/courses/102108078
4	https://nptel.ac.in/courses/112103306

SEMESTER S5

HEAT AND MASS TRANSFER

Course Code	PCMET503	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET403 Engineering Thermodynamics	Course Type	Theory

Course Objectives:

1. Apply heat transfer principles to solve engineering problems
2. Understand principles of various heat transfer equipments.
3. Apply mass transfer principles to solve engineering problems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Conduction heat transfer</p> <p>Modes of heat transfer – Mechanisms and laws of heat transfer – thermal conductivity, convective heat transfer coefficient, overall heat transfer coefficient</p> <p>General heat conduction equation in three dimension through plane (derivation needed) cylindrical and spherical (only equation) walls –initial and boundary conditions - One Dimensional Steady state heat conduction - Thermal Conductivity – concept of thermal resistance – critical radius – conduction with heat generation.</p> <p>Transient heat conduction – Lumped system analysis – transient heat conduction analysis of bodies with non-negligible internal temperature</p>	8

	<p>gradient.</p> <p>Heat transfer through extended surfaces – classification of fins – heat transfer rate from a fin (rectangular fin, pin fin) – boundary conditions – fin effectiveness and fin efficiency.</p> <p>Introduction to finite difference method for steady state heat conduction analysis.</p>	
2	<p>Convection heat transfer</p> <p>Forced convection – concept of thermal and hydrodynamic boundary layers (internal and external flows) – thermal diffusivity – momentum diffusivity – fluid friction and heat transfer relationship – developing and developed flows (hydrodynamic and thermal). Non dimensional number in heat transfer.</p> <p>External heat convection from flat plate/cylinder/ sphere during laminar and turbulent flow. Internal heat transfer in a circular pipe during laminar and turbulent flow. Analogy between heat and momentum transfer.</p> <p>Natural convection – natural convection heat transfer from vertical plate, horizontal and vertical cylinder.</p> <p>Heat exchanger – classification – design considerations and parameters – compact heat exchangers – effect of fouling- heat exchanger analysis – LMTD and NTU methods. Introduction to heat pipes.</p>	10
3	<p>Radiation heat transfer</p> <p>Basic laws of radiation heat transfer – Black, gray, diffuse and real surfaces - emission characteristics and laws of black body radiation - solid angle and radiation intensity – radiation heat exchange between two infinite and finite back surfaces – shape factors- radiation heat exchange between two infinite parallel diffuse gray surfaces. Electrical network analogy for radiation heat exchange. Radiation shields. Conduction shape factor.</p>	10
4	<p>Mass Transfer</p> <p>Introduction to mass transfer – diffusion coefficient – Fick’s law of</p>	8

	<p>diffusion- steady state diffusion in stationary medium- diffusion in moving medium- diffusion through a membrane.</p> <p>Convective mass transfer – non dimensional numbers – analogy between heat and mass transfer – correlations.</p> <p>Cooling of electronic equipments – need – various methods – influencing factors. Electric battery cooling – various methods - phase change material, fin cooling, air cooling, liquid cooling. (description only)</p>	
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Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To understand and apply the principles of heat conduction in engineering problems	K3
CO2	To analyse mechanisms of natural and forced heat convection and understand the factors influencing the design of heat transfer equipment.	K4
CO3	To understand the principles of thermal radiation and apply the principles for radiation shielding	K3
CO4	To understand the principles modern cooling techniques and solve mass transfer problems using correlations.	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of engineering heat and mass transfer	R. C. Sachdeva	New Age International Publishers	6 th edition, 2022
2	Heat and Mass Transfer elements	P.K Nag	Tata McGraw Hill	3 th edition, 2011
3	Heat and Mass Transfer – Fundamental and Application	Yunus A. Cengel and Afshin J. Ghajar	McGraw Hill	6 th edition, 2020
4	A text book on heat transfer	S.P. Sukhatme	Universities Press	4 th edition, 2005

Data Books permitted for reference in the final examination:				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Heat and Mass Transfer Data Book	C P Kothandaraman	New Age International Publishers	10 th edition, 2022
2	Heat and Mass Transfer Data Book	Domkundwar	Dhanpatrai & Co.	2016
3	Heat Transfer Data Book	Mahesh M. Rathore	Laxmi Publications Pvt Ltd	1 st edition, 2020

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Mechanical Engineering Design	J. E. Shigley	McGraw Hill	2003
2	Fundamentals of Machine Component Design,	Juvinall R.C, Marshek K.M.	John Wiley	5 th edition, 2011
3	Shigley's Mechanical Engineering Design	Richard G. Budynas, J. Keith Nisbett	McGraw Hill	11 th edition, 2020
4	Design of Machine Elements	M. F. Spotts, T. E. Shoup	Pearson Education	8 th edition, 2019

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/105/112105124/
2	https://archive.nptel.ac.in/courses/112/105/112105124/
3	https://archive.nptel.ac.in/courses/112/105/112105124/
4	https://archive.nptel.ac.in/courses/112/105/112105124/

SEMESTER S5

MANAGEMENT FOR ENGINEERS

Course Code	PBMET504	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	PBL

Course Objectives:

1. To develop ability to critically evaluate a variety of management practices in the contemporary context
2. To understand and apply a variety of management and organisational theories in practice
3. To create sustainable organisations.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Management: Art and science perspectives – External environment – Classical, neo – classical and modern management theories – Levels of managers and skill required – Systems approach Planning – Types of plans – Mission, Goal, Strategy, Programme, Procedure Organizing - Organization levels and span of control – Delegation – Organization structures – line and staff concepts	9
2	Leading and Controlling: Leading Vs Managing - Dimensions of Leadership - Leadership Behaviour and styles - Transactional and Transformational Leadership -Basic control process Decision Making: Steps, Decision under certainty, risk and uncertainty: Decision trees, EMV method, EOL method, MaxiMin criterion, MiniMaxcriterion, MiniMax regret criterion.	9

3	<p>Project Management: Network construction, AON, AOA diagrams – Redundancy – CPM and PERT networks – Scheduling computations – PERT time estimates – Probability of completion of project – crashing</p> <p>Human resource management: Manpower planning, recruitment, selection, placement, training, development, performance management - Motivation - mechanism and theories</p>	9
4	<p>Operations management – Introduction - Concept of Productivity and its measurement – Forecasting – moving average – weighted moving average</p> <p>Marketing management – Marketing mix – Market segmentation, Market targeting and product positioning – Product life cycle, Marketing strategies for different stages of product life cycle – Sales promotion and methods – Channels of distribution</p> <p>Corporate Social Responsibility</p>	9

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. Total of 8 Questions, each carrying 2 marks (8x2 =16marks) 	<ul style="list-style-type: none"> 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks. (4x6 = 24 marks) 	40

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop ability to critically analyse a variety of management practices in the contemporary context	K4
CO2	Examine the broad functions of management	K2
CO3	Demonstrate ability in decision making and productivity analysis	K3
CO4	Apply project management techniques to manage projects	K3
CO5	Understand the functional areas of management	K2
CO6	Introduce the concept of market, marketing and marketing strategies	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	-	2	-	-	2	2	-	-
CO2	3	-	-	-	-	2	-	-	-	-	-	-
CO3	2	3	2	-	-	-	-	-	-	-	-	-
CO4	2	2	2	-	-	-	-	-	-	-	3	-
CO5	3		2	-	-	-	-	-	-	-	-	-
CO6	3	2	2	-	-	-	-	-	2	-	-	-

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Essentials Of Management	Harold Koontz, Heinz Wehrich and Mark V. Cannice	McGraw Hill	11th Edition, 2020
2	Operations Management: Theory and Practice	B. Mahadevan	Pearson	3rd Edition, 2018
3	Principles of Management	P. C. Tripathi and P. N. Reddy	McGraw Hill	6th Edition, 2017

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Marketing Management	Philip Kotler, Kevin Keller, Alexander Chernev and Jagdish N. Sheth	Pearson	16th Edition, 2018
2	Human Resource Management: Text and Cases	K. Aswathappa and Sadhna Dash	McGraw Hill	10th Edition, 2023
3	Management: Principles and Practices	R. W. Griffin	Cengage	11th Edition, 2017

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	Practical	Presentation
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		30

1. Project Planning and Proposal (5 Marks)

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. Contribution in Progress Presentation and Question Answer Sessions (4 Marks)

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. Involvement in the Project Work and Team Work (3 Marks)

- Active participation and individual contribution
- Teamwork and collaboration

4. Execution and Implementation (10 Marks)

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

5. Final Presentation (5 Marks)

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

6. Project Quality, Innovation, and Creativity (3 Marks)

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches

SEMESTER S5

COMPUTATIONAL FLUID DYNAMICS

Course Code	PEMET521	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory

Course Objectives:

1. The finite difference methods and finite volume methods as a means of solving different types of differential equations that arise in fluid dynamics and heat transfer.
2. The fundamentals of numerical analysis, ordinary differential equations and partial differential equations related to fluid mechanics and heat transfer
3. The error control and stability considerations associated with numerical solutions.
4. A class of methods used in computational fluid dynamics for numerically solving the Navier-Stokes equations for 2D incompressible flows.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Computational Fluid Dynamics, Governing Equations of fluid flow and heat transfer, Conservative form of Navier-Stokes equation, General transport equation. Physical and mathematical classifications of partial differential equations. Elliptic, parabolic and hyperbolic equations, Comparison of experimental, theoretical and numerical approaches; applications of CFD.	9
2	Discretization-converting derivatives to their finite difference forms- Taylor's series approach and polynomial fitting approach. Central	9

	<p>difference, backward difference, and forward difference of first and second order derivatives. Solution of partial differential equations using finite difference equations. Discretization error, truncation error, round off error. Consistency and numerical stability. Iterative convergence, condition for convergence, rate of convergence. Termination of iteration. Boundary and Initial conditions</p>	
3	<p>Introduction to finite volume method. Finite volume method for steady one-dimensional conduction problems. one-dimensional transient heat conduction problems -explicit, implicit, Crank- Nicholson schemes, under and over relaxations, handling of boundary conditions; dealing with Dirichlet, Neumann, and Robins type boundary conditions; two-dimensional steady state conduction problems; point-by-point and line-by-line method of solution; tri-diagonal matrix algorithm.</p>	9
4	<p>Finite volume method for steady-state diffusion and convection-diffusion problems; Central difference and Upwind schemes for convection and diffusion problems. Two dimensional incompressible viscous flows. Staggered grid. Pressure correction methods. Solution algorithm for pressure-velocity coupling in steady flows- SIMPLE algorithm to solve Navier - Stokes equations. Computer graphics techniques to present CFD results.</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. Total of 8 Questions, each carrying 3 marks (8x3 =24marks) 	<ul style="list-style-type: none"> Each question carries 9 marks. Two questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. (4x9 = 36 marks) 	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To understand the governing equations of fluid flow and heat transfer.	K2
CO2	To apply finite difference methods to simple partial differential equations	K3
CO3	To demonstrate the use of finite volume method for simple 1D/2D problems	K3
CO4	To understand different solution techniques for convection diffusion equations	K2
CO5	To apply the knowledge of CFD to interpret the graphical results	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Computational Fluid Dynamics	John D Anderson Jr	McGraw-Hill Book Company	2012
2	Numerical Heat Transfer and Fluid Flow	S V Patankar,	McGraw-Hill	2017
3	An Introduction to Computational Fluid Dynamics: The Finite Volume Method	H. Versteeg, W.Malalasekera	Pearson	2nd, 2008

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Introduction to computational fluid dynamics	Anil W. Date	Cambridge University Press	2005
2	Introductory methods to analysis	S SSastry	PHI Learning Private	2012
3	Heat transfer	S P Venkatesh	Ane books Pvt Ltd	2009

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://nptel.ac.in/courses/112105045
2	https://onlinecourses.nptel.ac.in/noc20_me64/preview
3	https://nptel.ac.in/courses/112105045 https://onlinecourses.nptel.ac.in/noc21_me126/preview
4	https://onlinecourses.nptel.ac.in/noc21_me126/preview https://onlinecourses.nptel.ac.in/noc20_me64/preview

SEMESTER S5

DESIGN FOR MANUFACTURE AND ASSEMBLY

Course Code	PEMET522	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Manufacturing Process PEMET304	Course Type	Theory

Course Objectives:

1. To introduce the basic guidelines of different manufacturing processes.
2. To understand concepts of design for assembly to reduce number of parts and to optimize design.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to DFMA: History of DFMA, Steps for applying DFMA, Advantages of applying DFMA, Reasons for not implementing DFMA. Introduction to Manufacturing Process: Classification of manufacturing process, Basic manufacturing processes, Mechanical properties of materials, Introduction to materials and material selection, Classification of engineering materials, Material selection for product design, Process capability analysis.	9
2	Introduction to Assembly: The assembly process, Characteristics and applications, Economic significance of assembly, General taxonomies of assembly operation and systems, assembling a product. Design for Assembly: Introduction, Design consideration, DFA methodology, General Design Guidelines for Manual Assembly for Part Handling and for Insertion and Fastening, General Rules for Product Design for Automation, Design for Fasteners: Introduction, Design recommendation for fasteners. Design for disassembly.	9

3	<p>Design for machining: Introduction to machining, Recommended materials for machinability, Machining Using Single-Point Cutting Tools, Machining Using Multipoint Tools.</p> <p>Design for tuning operation: Process description, typical characteristics and applications, Suitable materials, Design recommendations.</p> <p>Design for machining round holes: Introduction, Suitable materials, Design recommendations.</p> <p>Design for milling: Process description, Characteristics and applications of parts produced on milling machines, Design recommendations.</p>	9
4	<p>Sand casting: Introduction to sand casting, typical characteristics of sand cast part, Design recommendations.</p> <p>Die casting: Introduction, Applications, Suitable material consideration, Design recommendations.</p> <p>Injection moulding: Introduction, Typical characteristics of injection moulded parts, Effect of shrinkage, Suitable materials, Design recommendations.</p> <p>Welding process: Different types of welding processes, Design recommendations.</p>	9

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks (8x3 =24marks) 	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. (4x9 = 36 marks) 	60

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the knowledge of Design Guidelines for Manual Assembly.	K3
CO2	Apply the knowledge of General design principles for manufacturability.	K3
CO3	Design and improve parts for better machinability.	K3
CO4	Design and improve parts for better casting and injection moulding.	K3
CO5	Design and improve parts for better welded joints.	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Product Design for Manufacture and Assembly	Geoffrey Boothroyd, Peter Dewhurst, Winston Knight	CRC press	Third Edition, 2010
2	Product design and Manufacturing	A.K. Chitale and R.C. Gupta	Prentice Hall of India	Fifth Edition, 2011
3	Engineering Design: A Materials and processing Approach	Dieter, G.E.	McGraw Hill Co. Ltd	2000
4	Design for Manufacturing and assembly	O. Molloy, S. Tilley and E.A. Warman	Chapman &Hall, London, UK	First Edition, 1998

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Design for Manufacturability Handbook	James G. Bralla	McGraw-Hill companies, New York	Second Edition, 1998
2	Assembly Automation and Product Design	Geoffrey Boothroyd	CRC press	Second Edition, 2005
3	Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development	D. E. Whitney	Oxford University Press, New York	2004
4	Industrial Design, Materials and Manufacture Guide	J. Lesko	John Willy and Sons, Inc	1999

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://nptel.ac.in/courses/107103012
2	https://nptel.ac.in/courses/107103012
3	https://nptel.ac.in/courses/107103012
4	https://nptel.ac.in/courses/107103012

SEMESTER S5

COMPUTER AIDED DESIGN AND ANALYSIS

Course Code	PEMET523	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To provide a foundational understanding of CAD, including its historical evolution, industrial applications, and key components such as geometric and solid modeling, CAD/CAM/CAE/CAPP packages, hardware, and software developments.
2. To develop proficiency in 2D and 3D computer graphics, focusing on transformations, drawing algorithms, solid modeling techniques, and coordinate systems, alongside foundational knowledge in finite element method (FEM) and finite volume method (FVM).

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to CAD, historical developments, industrial look at CAD, comparison of CAD with traditional designing, application of computers in design, basics of geometric and solid modeling, packages for CAD/CAM/CAE/CAPP, hardware in CAD components, user interaction devices, design database, graphic standards, data exchange formats, raster scan, random scan, various display systems, CAD software, latest developments in the area, PDM, PLM and CAD	9
2	Transformation of points and lines, 2-D rotation, reflection, scaling, combined transformation, homogeneous coordinates, shearing, orthographic and perspective projections, simple problems, line drawing algorithms, DDA algorithm, Bresenham's line algorithm, circle drawing	9

	algorithms, Bresenham's circle algorithm, curve drawing algorithms.	
3	3D graphics, algebraic and geometric forms, tangents and normals, blending functions, straight lines, conics, cubic splines, Bezier curves, B-spline curves, solid models and representation scheme, boundary representation, constructive solid geometry, sweep representation, cell decomposition, spatial occupancy enumeration, coordinate systems for solid modelling.	10
4	Introduction to finite element analysis, steps involved in FEM, pre-processing phase, discretization, types of elements, stiffness matrix Fundamentals of Finite volume methods, different types of finite volume grids, approximation of surface and volume integrals; interpolation methods, Review of governing equations	8

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the historical developments and industrial applications of CAD, including key components and latest software developments.	K1, K2
CO2	Apply 2D transformation techniques, including rotation, reflection, scaling, and line and curve drawing algorithms in CAD software.	K3
CO3	Apply 3D graphics and solid modeling techniques, such as Bezier and B-spline curves, and their application in creating complex geometric forms.	K3
CO4	Understand finite element analysis (FEA) and finite volume methods (FVM) including discretization, formulation, and boundary condition implementation for simple structural and fluid flow problems.	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	CAD/CAM Computer Aided Design and Manufacturing	M.P. Groover, E.M. Zimmers, Jr.	Prentice Hall of India	2014
2	CAD/CAM : Theory and Practice	Ibrahim Zeid, R Sivasubramanian	McGraw Hill Education	2 nd , 2009
3	Product Design and Development	Karl T. Ulrich, Steven D. Eppinger	McGraw Hill Education	7 th 2020
4	Introduction to Finite Elements in Engineering,	T. R. Chandrupatla and A. D. Belagundu	Pearson Education	2001

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	CAD/CAM – Principle Practice and Manufacturing Management,	Chris McMahon and Jimmie Browne	Addision Wesley England,	1998
2	Mathematical Elements in Computer Graphics,	D. F. Rogers and J. A. Adams	McGraw-Hill	1990
3	A First course in Finite Element Method	Daryl Logan	Thomson Learning	2007
4	Computer Graphics with open GL,	Donald Hearn, M. Pauline Baker and Warren Carithers	Pearson Education	2001

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/102/112102101/
2	https://archive.nptel.ac.in/courses/112/102/112102101/
3	https://archive.nptel.ac.in/courses/112/102/112102101/
4	https://archive.nptel.ac.in/courses/112/102/112102101/ https://archive.nptel.ac.in/courses/101/104/101104074/

SEMESTER S5

ADDITIVE MANUFACTURING

Course Code	PEMET524	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To demonstrate appropriate level of understanding on principles of additive manufacturing
2. To understand the different additive manufacturing technologies.
3. To choose appropriate materials for additive manufacturing processes
4. To design prototypes by identifying suitable process with optimum process parameters

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Additive Manufacturing (AM) –Basic principle of AM- Procedure of product development in AM process chain. Classification of additive manufacturing processes, Basic concept, Digitization techniques, Benefits and challenges in AM. Data processing for AM- CAD model preparation, Part orientation and support generation, Slicing methods, Tool path generation, STL Formats. Demonstration of slicing software packages.	8
2	Common AM technologies: Principle, materials, process parameters, advantages and applications of: Stereo Lithography (SLA), Digital Light Processing (DLP), Continuous Liquid Interface Production (CLIP), Laminated Object Manufacturing (LOM), Ultrasonic AM (UAM), 3D printing, Binder Jetting, Material Jetting, Fused Deposition Modelling	10

	(FDM), Direct Ink Writing (DIW).	
3	Common AM technologies: Principle, materials, process parameters, advantages and applications of: Selective Laser Sintering (SLS), Selection Laser Melting (SLM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing (WAAM), Laser Engineering Net Shaping(LENS).	10
4	Design for AM (DFAM) AM unique capabilities, DFAM concepts and objectives, Design freedom and synthesis methods. Applications for AM Applications: Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc.	8

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. Total of 8 Questions, each carrying 3 marks <p align="center">(8x3 =24marks)</p>	<ul style="list-style-type: none"> Each question carries 9 marks. Two questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. <p align="center">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the concept of AM from conventional manufacturing systems.	K2
CO2	Understand the data processing techniques in AM process	K2
CO3	Understand the principles of AM processes.	K2
CO4	Create components using AM process.	K6
CO5	Understand the key aspects in design a product using AM.	K2
CO6	Understand the application of AM in industries	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing.	Gibson I D. W. Rosen I and B. Stucker	Springer	Second Edition, 2015
2	Rapid prototyping: Principles and applications	Chua, C.K., Leong K.F. and Lim C.S.	World Scientific Publishers	Third edition, 2010.

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Rapid Manufacturing The Technologies and Applications of Rapid Prototyping and Rapid Tooling	D.T. Pham and S.S. Dimov	Springer London Ltd	Softcover reprint of the original 1st ed. 2001, 2011
2	Additive Manufacturing: Principles, technologies and Application	C.P. Paul, A.N. Jinoop	McGraw Hill	First Edition, 2021
3	Additive Manufacturing Technologies	S. Shiva, Anuj K. Shukla	Wiley	First Edition, 2024
4	Additive Manufacturing: Fundamentals and Advancements	Manu Srivastava, Sandeep Rathee, Sachin Maheshwari	CRC Press	First Edition, 2019

Video Links (NPTEL, SWAYAM...)	
NPTEL	NOC: Fundamentals of Additive Manufacturing Technologies, IIT Guwahati by Prof. Sajan Kapil Link: https://nptel.ac.in/courses/112103306

SEMESTER S5

ENERGY ECONOMICS AND POLICY

Course Code	PEMET526	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To learn and understand the set of policies that has developed to regulate energy-related behaviour, as well as the economic concepts that direct the actions of energy producers and consumers.
2. To understand different facets of energy supply and demand, with an emphasis on policies that support sustainable energy supply, learn the relationship between energy, the environment, and emission reduction strategies

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Energy as a resource and its accounting, Government role in innovation. Introduction, Energy as a system, What is the System of Economic Accounting for Energy, Government's role in mobilising investment and innovation in energy, The importance of the investment environment.</p> <p>Energy Efficiency Characteristics, energy supply and demand analysis. A review of energy efficiency measures (EEM) characteristics, Adoption and measures of EEM, Supply and Demand Analyses, Energy demand science for a decarbonized society.</p> <p>Energy statistics influence on energy consumption for oil rich countries. Global Influence of Oil-Rich Countries, Oil-Rich Countries Statistics, Geo-</p>	9

	Political Influence, Energy Transitions, Energy Policy Shifts.	
2	<p>Behaviour Change Approach to Promote and Sustain Energy Efficiency. Behaviour gaps, Biases, design thinking methodology, Ripple effect.</p> <p>Drivers of human behaviour to meet UN SDGs in relation with Energy. Role of individuals in attaining SDGs, Behavioural aspects in energy modelling, Behaviour changes for sustainable development.</p> <p>Energy efficiency and emission abatement relations. Abatement of emissions through energy efficiency, Sector wise analysis, Harnessing Renewable Energy Potential (Some country case studies).</p>	9
3	<p>Energy Market Analysis, Regulations by Government of India. Scenario analyses, feasible options for developing an energy future, the impacts, costs, and financial risks of the various scenarios for transitioning to the energy future, market penetration pathways.</p> <p>The Economics of Depleting Resources & The Oil Sector Examples. Resource depletion and overuse, combating resource depletion and Misuse and pollution, The Prospects for Greener Growth-Policies and Politics of Low-Carbon Growth.</p> <p>Unregulated Markets and Technological Change: oil and natural gas sector examples. The Emergence of Markets, Natural Gas Market, Transportation Market, Markets in Other Segments of the Gas Industry, Trading Models in the Deregulated Natural Gas Industry, Under development and unregulated markets: Reasons why unregulated markets reproduce underdevelopment.</p>	9
4	<p>Carbon Emission: Recent Trends and Shift in Policies in India, case studies of different countries. Sector wise emission trends in India, electricity, industry, transportation, buildings, agriculture, policies, case study of other countries.</p> <p>Hydrogen: A Pathway to Carbon Neutral Economy, possibilities and approaches. Hydrogen production and potential utilization, technical challenges, codes and standards development-Public awareness and social</p>	

	<p>acceptance.</p> <p>Energy efficient policies to achieve SDGs for countries, Importance of Conference of parties (COP). Energy Policy: A Foundation for Transition- Energy Transition: A Paradigm Shift, Future Prospects and Emerging Trends, The Link Between Energy Policy, Energy Transition, and Sustainability in Oil-Rich Countries, Energy Policy Research A Pathway to Achieve UN (SDGs).The Role of COP in Emission Abatement, COP Goals, Agenda, Major Outcomes of COP</p>	9
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Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To enhance the vision while making any energy related decision on supply and demand.	K2
CO2	To understand the energy efficiency and behaviour change approaches.	K3
CO3	To understand the energy market and energy economics pertaining to oil rich economies	K3
CO4	To know the energy policies and emission abatement strategies	K3
CO5	To understand UN SDGs and COP	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Energy Economics: Concepts, Issues, Markets and Governance. (Selected chapters)	Bhattacharyya, Subhes. C.	Springer. London, UK.	2011
2	Energy Policy: Perspectives, Challenges and Future Directions (Selected chapters)	K J Sreekanth	Nova Publishers USA	2018

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Energy Efficiency Improvements with Emission Abatement for Energy Sustainability	K J Sreekanth	Springer Nature Singapore Pte Ltd.	2024
2	“The Economics of Exhaustible Resources,”	Hotelling, Harold,	Journal of Political Economy,	Vol. 39, No. 2 (April 1931), pp. 137-175
3	An Introduction to Energy Economics. In Stevens, P.(ed.)	Stevens, P.	The Economics of Energy, Vol.1, Edward Elgar, Cheltenham, UK.	2000

SEMESTER S5

HUMAN RESOURCES MANAGEMENT

Course Code	PEMET527	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Understand the HRM Concepts in organisation.
2. To familiarise the Recruitment & selection process
3. To familiarize the Career Development ways in an organization.
4. Acquire the knowledge about Employee safety measures and Labour activities

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	HUMAN RESOURCE MANAGEMENT: Concept of Human Management in a system-Organisation and Function of the HR. Objectives and Characteristics of HRM. Role of HR manager-Responsibility-Competitiveness- HR policies -HRM Concepts. JOB ANALYSIS & JOB DESIGN: Job Analysis- Job title- duties & essential functions- job specification -Techniques & Approaches in Job Analysis .Job design -considerations in job design-Types of Job design approaches.	9
2	HR PLANNING: Definition-HR planning system- HR forecasting— Importance of HR Planning- Human resource information system. RECRUITMENT & SELECTION: Concept of Recruitment- objectives- Sources of Recruitment- Internal & External sources-Recruitment process-	9

	Common constraints in recruitment. Selection- Selection Process-Screening-Employment Test-Interview- Physical Examination-Job offer, Various Approaches in Hiring Decisions.	
3	<p>TRAINING: Training- Need for training- Induction training-Effective training Programme process-Structural issues in Training.</p> <p>CAREER DEVELOPMENT: Employee development methods-performance management -Components of effective performance management -performance appraisal- purposes of appraisal – methods of performance appraisal- promotion -transfers.-Incentive systems- Employee Benefits.-Types of Benefit schemes.</p>	9
4	<p>LABOUR RELATIONS: Relation between management and labours-Labour unions -objectives- Collective Bargaining -Negotiations-Strikes-Grievance Handling-Grievance redressal methods.</p> <p>EMPLOYEE SAFETY AND HEALTH: Employee safety- awareness – Accident prevention -creating safe environment -employee health problems and preventive measures-job stress – employee assistance programmes.</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none">• 2 Questions from each module.• Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none">• Each question carries 9 marks.• Two questions will be given from each module, out of which 1 question should be answered.• Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To familiarise with the basic concepts in HR Management	K1
CO2	Evaluate the Job design & analysis methods.	K2
CO3	Identify the Recruitment and selection methods.	K1
CO4	Understand the training process of Employees	K1
CO5	Understand various career development procedures.	K1
CO6	Analyse the various employee issues in an organisation	K3
CO7	Identify various safety issues and stress faced by employees	K1

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	-	-	-	-	1	-	-	-	-	1
CO2	2	-	-	-	-	-	-	-	-	-	1	1
CO3	1	-	-	-	-	1	1	-	-	-	-	1
CO4	1	1	-	-	-	-	-	-	-	-	1	1
CO5	1	1	-	-	-	1	-	-	-	-	-	1
CO6	2	1	-	-	-	-	1	-	-	-	1	2
CO7	2	-	-	-	-	-	-	-	-	-	-	1

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Human Resource Management	Gary Dessler	Pearson Publication	15th Edition (2016)
2	International Human Resource Management	Srinivas R Kandula	SAGE publication	2nd Edition (2018)
3	Human Resource management -Text and Cases	K. Aswathappa, Sadhna Dash	McGrawhill	10th Edition (2023)
4	Human Resource Management	Dr. TRaju, Dr. S Jayabharathi	Biztantra publications	1 ST Edition (2014)

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Human Resource Management and Digitalization	Franca cantoni, Gianlugi Mangia	Routledge publication	1 st Edition 2020
2	Human Resource Management	Jacquina Gilbert	Vibrant publishers	1st Edition 2019

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/110/105/110105069/
2	https://archive.nptel.ac.in/courses/110/105/110105069/
3	https://archive.nptel.ac.in/courses/110/105/110105069/
4	https://archive.nptel.ac.in/courses/110/105/110105069/

SEMESTER S5

OPERATIONS RESEARCH

Course Code	PEMET528	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3: 0: 0: 0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To understand the role of Operations Research (OR) in decision making
2. To apply different OR techniques for solving managerial problems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Operations Research (OR) and Linear Programming: Basics of OR, Modelling approach, Linear Programming (LP), Formulation of LP models, Graphical method, Simplex method, Big-M Method. Transportation Problem: Mathematical Formulation, Initial Basic Feasible Solution, North West Corner method, Least Cost method, Vogel's Approximation Method, Optimality test by MODI method, Assignment problem, Hungarian method.	9
2	Sequencing Problem: Basic terminologies, Processing of n Jobs through 2 machines, Processing of n Jobs through 3 machines, Processing n Jobs, through m machines. Game Theory: Games with saddle points, Games without saddle points – 2 x 2 games, Graphical method for m x 2 & 2 x n games	9

3	Non-traditional Optimization Techniques: Genetic Algorithm (GA) – Working principles, GA Operators, Parameters setting, Constraints handling, Solving simple problems using GA. Simulated Annealing and Particle Swarm Optimization (Theory only) - Introduction, Key concepts, Algorithm.	9
4	Scope of queuing theory, Importance and applications, Kendall’s Notations, Characteristics of Queuing Systems, Performance Measures in Queuing Systems, Classic Queuing Models, Single-server exponential arrival and service times, Two-server exponential arrival and service times.	9

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To formulate and solve linear programming problems and transportation problems	K2, K3
CO2	To apply basic sequencing techniques for processing jobs through machines	K2, K3
CO3	To solve simple problems in game theory	K2, K3
CO4	To apply evolutionary algorithms for optimization problems	K2, K3
CO5	To solve problems using classical queuing theory models	K2, K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

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

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Operations Research-Principles and Applications	Srinivasan, G.	PHI Pvt. Ltd.	Third Edition, 2017
2	Operations Research	Prem Kumar Gupta & D. S. Hira,	S Chand publication	Third Edition, 2008
3	Quantitative Techniques in Management	N. D Vohra. Hitesh Arora	McGraw Hill.	Sixth Edition, 2021
4	Soft Computing Fundamentals and Applications	Dilip K. Pratikar	Alpha Science	2015

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Optimization: Theory and Applications	Rao, S.S.	Wiley eastern.	Second edition,
2	Introduction to Operations Research,	F. S. Hillier& G. J. Leiberman:	McGraw Hill	Eleventh Edition
3	Operations Research Principles and Practice	Ravindran, Phillips and Solberg,	Willey & Sons	1987
4	Operations Research,	Goel, B. S. and Mittal, S. K.,	Pragati Prakashan, Meerut	1999

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://onlinecourses.nptel.ac.in/noc24_ma55
2	https://onlinecourses.swayam2.ac.in/cec24_ma05
3	https://onlinecourses.swayam2.ac.in/cec24_ma05
4	https://onlinecourses.swayam2.ac.in/cec24_ma05

SEMESTER S5

INSTRUMENTATION AND CONTROL SYSTEMS

Course Code	PEMET525	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To understand the basic principles of instrumentation.
2. Familiarize with various types of sensors and transducers used for measuring physical quantities
3. Gain knowledge of the fundamental concepts of control systems including open-loop and closed-loop systems.
4. Learn about system dynamics, mathematical modelling of physical systems and stability analysis of LTI systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Industrial measurement systems – different types of industrial variables and measurement systems elements. Sensors– Sensor components - Resistive sensors - Inductive sensors - Capacitive sensors - Thermoelectric sensors - Piezoelectric sensors. Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers- modes of operation-force transducer, Load cell, Strain gauge etc.	9
2	Industrial signal conditioning systems- Operational amplifiers - Amplifier circuits with ideal operational amplifiers - Current-to voltage converters - Inverting voltage amplifiers - Non-inverting voltage amplifiers - Differential amplifiers -Instrumentation amplifiers . Filters – Passive filters - First and second order RC-filters - Low-pass first-order RC-filter – High pass first-	9

	order RC-filter – Band pass filters , A/D converters for industrial measurements systems. Data Acquisition Systems(DAS) –Objectives of DAS.	
3	System Modeling- Open loop and closed loop control systems ,Transfer function of LTI systems- Electrical, translational and rotational systems – Force voltage and force current analogy Block diagram representation - block diagram reduction, Signal flow graph - Mason's gain formula. Control system components: Transfer functions of DC and AC servo motors– Control applications of Tacho generator and Stepper motor. Characteristic equation of Closed loop systems. Controllers- P, PI, and PID controllers.	9
4	Time domain analysis of control systems: Time domain specifications, Impulse and Step responses of first order and second order systems. Error analysis: Steady state error analysis - static error coefficients of type 0,1,2 systems. Stability Analysis: Concept of stability— Routh's stability criterion, Root locus method. Frequency Domain Analysis: Frequency Domain Specifications, Stability in Frequency Domain, Gain Margin, Phase Margin, Bode Plot, Polar Plot, Nyquist Plot.	9

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To get basic knowledge about industrial measurement system and different elements involved in it.	K2
CO2	Acquire knowledge about sensors and transducers for different industrial variables	K4
CO3	Acquire knowledge about signal conditional circuits like amplifiers, filters, ADC, etc. for working industrial measurement systems	K4
CO4	To describe the role of various control blocks and components in feedback systems	K3
CO5	To analyse the time domain responses of the linear systems and apply Root locus technique to assess the performance.	K4
CO6	Analyse the stability of the given LTI system	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	C	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-
CO3	3	1	-	-	-	-	-	-	-	-	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	3
CO5	3	3	3	-	2	-	-	-	-	-	-	3
CO6	3	3	3	-	-	-	-	-	-	-	-	3

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Industrial Instrumentation	K Krishnaswamy	New Age International Publishers, New Delhi	2003
2	Measurement systems applications and design	Ernest O. Doebelin	McGraw- Hill Publishing Company	1990
3	Control Systems Engineering	Nise N.S.	Wiley Eastern	6/e
4	Modern Control Engineering	Ogata K	Prentice Hall of India.	5/e
5	Control Systems	K R Varmah	Tata McGrawHill Tata McGrawHill	2010

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Principles of Industrial Instrumentation	Patranabis D	McGraw-Hill Education	3rd Edition, 2017
2	Industrial Instrumentation and Control	Singh, S.K	Tata McGraw-Hill Education	2009
3	Control Systems Principles and Design	Gopal M	Tata McGraw Hill	, 4/e
4	Automatic Control Systems	Kuo B. C	Prentice Hall of India	7/e

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://nptel.ac.in/courses/108105064
2	https://nptel.ac.in/courses/108105062
3	https://nptel.ac.in/courses/107106081
4	https://nptel.ac.in/courses/107106081

SEMESTER S5

THERMAL ENGINEERING LAB-1

Course Code	PCMEL507	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET403 Engineering Thermodynamics	Course Type	Lab

Course Objectives:

1. To conduct experiment for measuring viscosity, flash and fire point and Calorific value of petroleum products
2. To conduct the various heat transfer experiments

Expt. No.	Experiments
1	Determination of viscosity of lubricating oils and fuels and its variation with Temperature
2	Determination of flash and fire points of petroleum fuels and oils
3	Determination of calorific value of solid and liquid fuels- Bomb Calorimeter
4	Determination of calorific value of gaseous fuels –Gas Calorimeter
5	Calibration of Thermocouples
6	Determination of LMTD and effectiveness of parallel flow, Counter flow and cross flow heat exchangers
7	Performance studies on a shell and tube heat exchanger
8	Development of heat transfer correlation for heat exchangers/condenser using modified Wilson Plot Method

9	Determination of heat transfer coefficients in free convection
10	Determination of heat transfer coefficients in forced convection
11	Determination of thermal conductivity of solids (composite wall/metal rod)
12	Determination of thermal conductivity of powder
13	Determination of thermal conductivity of liquids
14	Measurement of unsteady state conduction heat transfer
15	Determination of emissivity of a specimen
16	Determination of Stefan Boltzman constant
17	Measurement of solar radiation
18	Experimental study of dropwise and filmwise condensation
19	Experiments on boiling heat transfer
20	Performance study on heat pipe
	Note : 10 Experiments are mandatory

**Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- *Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.*
- *Endorsement by External Examiner: The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Measure thermo-physical properties of solid, liquid and gaseous fuels	K4
CO2	Evaluate thermal properties of materials in conduction, convection and radiation	K4
CO3	Analyse the performance of heat exchangers and heat pipes	K4
CO4	Measure solar radiation	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	-	-	-	3	3	-	-
CO2	3	-	-	2	-	-	-	-	3	3	-	-
CO3	3	-	-	2	-	-	-	-	3	3	-	-
CO4	3	-	-	2	-	-	-	-	3	3	-	-

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Heat Transfer a Practical Approach	Yunus A. Cengel	Tata McGraw-Hill Education	4th Edition, 2012.
2	Fundamentals of Engineering, Heat and Mass Transfer	R. C. Sachdeva	New Age publication,	3 rd Edition, 2012.
3	Heat transfer	Holman J.P	Mc Graw-Hill	10th. Ed., 2009
4	Heat and Mass Transfer	Frank P. Incropera and David P. Dewitt	John Wiley and sons	2011
5	Fundamentals of Heat and Mass Transfer	Kothandaraman C.P	New Age International, New Delhi.	2006

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.

- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S5

MECHANICAL ENGINEERING LAB

Course Code	PCMEL508	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET402	Course Type	Lab

Course Objectives:

1. To get an idea of the dimensional & form accuracy of products
2. To get exposure to equipment and exercises related to machine dynamics, basics of hydraulic and pneumatic devices, basic concepts of stepper motors, basic ideas of data acquisition systems and automation

Expt. No.	Experiments
PART 1 (Any six experiments)	
1	Calibration of vernier caliper, micrometer, LVDT and dial gauge. Determine the class of fits between the given shaft and hole. etc Study and analysis of repeatability and reproducibility
2	Angular measurements using sine bar, bevel protractor, combination sets, clinometers, angle dekkor etc.
3	Measurement of straightness, flatness, squareness and roundness error using autocollimator, Laser interferometer, spirit level, dial gauge etc.
4	Measurement of displacement, velocity and acceleration of vibration.
5	Measurement of surface roughness of turned, milled, grounded, lapped surfaces and glass etc.
6	Measurement of strain using strain gauges and strain indicators using various bridge arrangements
7	Measurement of screw thread parameters

8	Measurement of gear profile error and other parameters
9	Bore diameter measurement
10	Use of Tool maker's microscope
11	Analysis of automobile exhaust gas and flue gas.
12	Demonstration of Coordinate Measuring Machine for the evaluation of form errors
	PART 2 (Any six experiments)
1	Experiment on Whirling of shaft
2	Experiment on Gyroscope
3	Experiment on Universal governor apparatus
4	Experiment on Free and forced vibration analysis
5	Experiment on any Non-destructive testing.
6	Exercises on hydraulic and pneumatic circuits using trainer units
7	Exercises on electro-pneumatic and electro-hydraulic circuits using trainer units
8	Exercises on Motion controller using AC/DC motor, servo motors and stepper motors with encoders to determine the operating characteristics.
9	Exercises on PC-based data acquisition systems with any software.
10	Study of PLC programming, Controlling variable speed drive through PLC
11	Exercises on the robotic trainer units
12	Exercises on 3-D printing

A minimum of 12 sets of experiments are mandatory

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- *Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.*
- *Endorsement by External Examiner: The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Choose the appropriate instruments for different measurements	K3
CO2	Determine dimensional and form accuracies of various components	K3
CO3	Develop knowledge of designing and analyzing mechanisms in machinery	K3
CO4	Demonstrate the functions and control of various devices used for industrial automation	K3
CO5	Demonstrate 3D printing technique	K3

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

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

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Metrology for Engineers, 5th edition	Shotbolt C.R. and Gayler J.F.W,	ELBS, London	
2	Practical Engineering Metrology	Sharp K.W.B. and Hume	Sir Isaac Pitman and sons Ltd, London	
3	Kinematics and Dynamics of Machinery	C.E.Wilson, P. Sadler	Pearson Education	2005
4	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	W.Bolton	Person Education Limited, New Delhi	2007

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Engineering Measurements	Collett, C.V. and Hope, A.D	Second edition, ELBS/Longman	
2	Machines and Mechanisms Applied Kinematic Analysis	D.H.Myskza	Pearson Education	2013
3	Mechatronics: Integrated Mechanical Electronic Systems	K.P.Ramachandran, G.K.Vijayaraghavan, M.S.Balasundaram	Wiley India Pvt. Ltd., New Delhi	2008

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.

- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity,

SEMESTER 6

MECHANICAL ENGINEERING

SEMESTER S6

INDUSTRIAL AND SYSTEMS ENGINEERING

Course Code	PCMET601	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3: 0: 0: 0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To impart knowledge about various tools and techniques of Industrial Engineering.
2. To facilitate students to acquire knowledge about inventory management, lean manufacturing, agile manufacturing, enterprise resource planning and thus inculcate the skills needed to apply these principles in an organization.
3. To get acquainted with quality management practices

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Introduction: Scope and functions of Industrial Engineering - Types of production (batch, flow and unit), Roles of line supervisors and production managers.</p> <p>Product Development and Design: Objectives - Quality and cost considerations - Human factors in design - Detailed design & prototyping - Functionality & manufacturability - Standardization, simplification and variety reduction - Concurrent engineering.</p> <p>Plant layout and Material handling: Types of plant layout - Principles of material handling - Material handling equipment – Types, selection and application.</p>	9
2	<p>Production Planning and Control: Aggregate production planning, materials requirement planning - Inventory Management: EOQ models, discount models,</p>	9

	<p>P system, Q system, reorder level – Selective inventory control techniques - JIT - Supply chain and management.</p> <p>Break down, preventive and predictive maintenance.</p>	
3	<p>Lean Manufacturing (LM): Basic elements – Tools - Concept of wastes - stages of 5S and waste elimination - Need for LM.</p> <p>Agile manufacturing: Definition, business need, conceptual frame work, characteristics and generic features - Approaches to enhance agility in manufacturing - Managing people in agile organization.</p> <p>Enterprise resource planning (ERP): Concept of Enterprise, ERP Overview - Integrated information system - ERP implementation – Benefits, challenges, success and failure factors - Business Process Reengineering (BPR), Customer relationship management (CRM).</p>	9
4	<p>Quality Management: Quality, quality planning, quality control, quality assurance, quality management – TQM, ISO, Six Sigma and Quality circle (Brief description only).</p> <p>Statistical Quality Control - Process capability - Causes of variation in quality- Control charts for \bar{x} and R – Acceptance sampling.</p> <p>Reliability Engineering - Causes of failures - Bath tub curve - System reliability - Life testing.</p>	9

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Implement various tools and techniques in industrial engineering	K3
CO2	Apply inventory control techniques for materials management	K3
CO3	Identify the framework of lean and agile manufacturing	K2
CO4	Identify core and extended modules of enterprise resource planning	K2
CO5	To be conversant with important terms for quality management in organizations	K2
CO6	Implement different quality control techniques	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	-
CO2	2	3	2	-	-	-	-	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-	-	-	-	-
CO4	3	2	2	-	2	-	-	-	-	-	-	-
CO5	3	2	2	-		-	-	-	-	-	-	-
CO6	2	2	3	-	2	-	-	-	-	-	-	-

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Industrial Engineering & Production Management	M. T. Telsang	S Chand	3rd Edition, 2018
2	Production and operations management	R. Paneerselvam	PHI	3rd Edition, 2012
3	Operations Management: Theory and Practice	B. Mahadevan	Pearson	3rd Edition, 2018

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Industrial Engineering and Management – A new perspective	Philips E. Hicks	McGraw Hill	2nd Edition, 1994
2	Statistical Quality Control	Montgomery	Wiley Eastern	6th Edition, 2010
3	Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities	S. R. Devadasan, V. M. Sivakumar, R. Muruges and P. R. Shalij	PHI Learning	1st Edition, 2012
4	Operations Management: Processes and Supply Chains	L. J. Krajewski, M. K. Malhotra, S. K. Srivastava and L. P. Ritzman	Pearson Education	12th Edition, 2019

SEMESTER S6

MACHINE DESIGN

Course Code	PCMET602	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET302 Mechanics of Solids	Course Type	Theory

Course Objectives:

1. To review concepts of statics and strength of materials.
2. To introduce fundamental approaches to failure prevention of components.
3. To provide knowledge in the design of common machine elements such as fasteners, springs, belts and pressure vessels.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Design- Definition, steps in design process, preferred numbers, standards and codes in design. Materials and their properties- Elastic and plastic behaviour of metals, ductile and brittle behaviour, shear, bending and torsional stresses, Factor of safety, stress concentration, combined stresses, stress concentration factor. Notch sensitivity, Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, Design for fatigue loading; Combined steady and variable stress- Gerber, Goodman and Soderberg method	10
2	Design of riveted joints- Material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints Design of welded joints- welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under	9

	bending, eccentrically loaded welds.	
3	Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading, surging, critical frequency, concentric springs, end construction. Leaf springs- Flat springs, semi elliptical laminated leaf springs, design of leaf springs, nipping	9
4	Design of flat belt- materials for belts, slip of the belts, creep, centrifugal tension. Design of V-belt drives, Advantages and limitations of V-belt drive Cylinders and Pressure vessels, thin cylinders, thick cylinders, Open and closed vessels, Lamé's, Clavarino's and Birnie's equations. Dilation.	8

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none">• 2 Questions from each module.• Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none">• Each question carries 9 marks.• Two questions will be given from each module, out of which 1 question should be answered.• Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Interpret component behavior subjected to static and fatigue loads and identify the failure criteria	K3
CO2	Analyze the load carrying capacity of riveted joints, and welded joints	K4
CO3	Analyze stress carrying capacity and deformation of helical and leaf springs	K4
CO4	Analyze the load carrying capacity of belts and pressure vessels	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	-	-	2	2	-	-	-	2
CO2	3	3	3	-	-	-	2	2	-	-	-	2
CO3	3	3	3	-	-	-	2	2	-	-	-	2
CO4	3	3	3	-	-	-	2	2	-	-	-	2

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Machine Design – An Integrated Approach	RobertL. Norton	Pearson Education	5 th edition, 2018
2	Design of Machine elements	V.B.Bhandari	Tata McGraw Hill	5 th edition, 2020
3	Design of Machine elements,	Jalaludeen	Anuradha Publications, Chennai	2014
4	A Text book of Machine Design	Dr. P. C. Sharma, Dr. D. K. Aggarwal	S.K. Kataria & Sons	2017

Data Books permitted for reference in the final examination:			
Design Data Hand Book	K. Mahadevan, K.Balaveera Reddy	CBS Publishers & Distributors	4 th edition, 2019
PSG Design DataHand book	PSG Tech	DPV Printers, Coimbatore	2022
Machine Design Data Handbook	NarayanaIyengar B.R, Lingaiah K	Tata McGraw Hill/Suma Publications	1984

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Mechanical Engineering Design	J. E. Shigley	McGraw Hill	2003
2	Fundamentals of Machine Component Design,	Juvinall R.C, Marshek K.M.	John Wiley	5 th edition, 2011
3	Shigley's Mechanical Engineering Design	Richard G. Budynas, J. Keith Nisbett	McGraw Hill	11 th edition, 2020
4	Design of Machine Elements	M. F. Spotts, T. E. Shoup	Pearson Education	8 th edition, 2019
5	MachineElements: Life and Design	Boris M Klebanov, David M. Barlam, Frederic E. Nystrom	CRC Press	2019

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/105/112105124/
2	https://archive.nptel.ac.in/courses/112/105/112105124/
3	https://archive.nptel.ac.in/courses/112/105/112105124/
4	https://archive.nptel.ac.in/courses/112/105/112105124/

SEMESTER S6

POWER PLANT ENGINEERING

Course Code	PEMET631	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To develop a comprehensive understanding of steam, gas, hydro and nuclear power plants and various energy storage systems.
2. To familiarise various terms related to power plant economics.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Analysis of Steam Cycle Steam engineering-temperature entropy diagram- mollier diagram-Rankine cycle-steam power plant, internally irreversible and externally irreversible Rankine cycle-Mean temperature of heat addition-Effect of superheat and inlet pressure-Reheating of steam, Regeneration-Regenerative feed water heating-Feed water heaters-Efficiencies in a steam power plant-binary vapor cycle	9
2	Steam generator classifications Cochran boiler-Lancashire boiler-Cornish boiler-locomotive boiler-Babcock and Wilcox boiler Stirling boiler-high pressure boilers-boiler mountings and accessories Steam nozzles Flow through steam nozzles-throat pressure for maximum discharge-effect of friction-super saturated flow	9

	<p>Steam turbines</p> <p>Impulse and reaction turbines-velocity diagram-condition for maximum efficiency-compounding-reheat factor-blade height-governing of steam turbines-cogeneration and combined cycle power generation</p>	
3	<p>Thermal power plants</p> <p>General layout-site selection-fuel handling, storage and burning systems-dust and ash handling system-chimney draught</p> <p>Nuclear power plants</p> <p>Classification-components-safety measures-effects of nuclear radiation-nuclear waste disposal.</p> <p>Gas turbine power plants</p> <p>Classification-closed open and other systems</p> <p>Hydro Electric Power Plants</p> <p>Classification- Typical Layout and associated components</p>	9
4	<p>Energy Storage</p> <p>Pumped hydro, Compressed air energy storage, flywheel energy storage, Electrochemical energy storage, magnetic energy storage, Thermal energy storage, Chemical energy storage</p> <p>Economics of power generation</p> <p>Estimation of load-load curve-load factor-diversity factor-capacity factor-use factor-economics in plant selection-economics of generation and distribution of power-useful life-tariff for electrical energy.</p> <p>Environmental pollution and its control</p> <p>Pollutants from power plants-control of pollutants-control of particulate matter -Control of SO₂- control of wastewater from steam power plants-pollution from nuclear power plants-noise pollution and noise control</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the layout, components and working of steam, gas, hydro, and nuclear power plants.	K2
CO2	Calculate the performance parameters of simple and modified Rankine cycles.	K3
CO3	Calculate the performance parameters of steam turbines and steam nozzles.	K3
CO4	Explain the working of various energy storage systems	K2
CO5	Discuss the economics of power generation and pollution from power plants and their effect on the environment	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Power Plant Technology	M. M. El Wakil	McGraw Hill Education	1, 2017
2	Power Plant Engineering	P. K. Nag	McGraw Hill Education	4, 2017

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Power Plant Engineering	G. R. Nagpal, S. C. Sharma	KHANNA Publishers	16, 2012
2	Power Plant Engineering	Manoj Kumar Gupta	PHI Learning Pvt. Ltd	1, 2012

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/107/112107291/
2	https://archive.nptel.ac.in/courses/112/107/112107291/
3	https://archive.nptel.ac.in/courses/112/107/112107291/
4	https://archive.nptel.ac.in/courses/112/107/112107291/

SEMESTER S6

COMPRESSIBLE FLUID FLOW

Course Code	PEMET632	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET303	Course Type	Theory

Course Objectives:

1. To provide a foundation in compressible fluid mechanics, focusing on steady, one-dimensional flow problems.
2. To familiarise property variations across normal and oblique shock waves

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Fundamentals of compressible flow: Various regimes of flow, Reynolds transport theorem-Governing equations for compressible flows. Mach number, Mach waves, Mach cone and Mach angle, Sonic boom. Concept of stagnation state, stagnation properties. Adiabatic energy equation, various regions of flow, adiabatic ellipse One Dimensional isentropic flow: adiabatic and isentropic flow of a perfect gas, isentropic flow in ducts of varying cross-sections, nozzles, mass flow rate, critical properties, choking, impulse function, operation of nozzle under varying pressure ratios-Use of gas tables.	10
2	Flow in constant area duct with friction: Assumptions, Governing equations, Fanno curve on h-s and P-v diagram, Fanno flow relations for a perfect gas, variation of Mach number with duct length, choking due to friction, Use of gas tables for Fanno flow. Isothermal flow (elementary idea only)	8

3	Flow through constant area duct with heat transfer (Rayleigh Flow): Assumptions, Governing equations, Rayleigh line on h-s and P-v diagram, Rayleigh relation for perfect gas, maximum possible heat addition, location of maximum enthalpy and entropy points, thermal choking, Use of gas tables for Rayleigh flow.	9
4	Irreversible discontinuity in supersonic flow: Development of shock wave, types of shock waves, governing equations, strength of shock waves, normal Shock on T-S diagram, Prandtl-Mayer relation, Rankine-Huguenot relation, Mach number downstream of normal shock, variation of flow parameters across the normal shock, normal shock in Fanno and Rayleigh flows, Use of gas tables for normal shocks. Oblique shock waves - supersonic flow over compression and expansion corners (elementary idea only). Wind tunnel types, measurement of velocity, pressure, and temperature.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination- 1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic concepts of compressible fluid mechanics and	K3
CO2	Analyze problems in one dimensional isentropic compressible flow.	K4
CO3	Analyze problems of flow in constant area duct with friction.	K4
CO4	Analyze problems of flow in constant area duct with heat transfer.	K4
CO5	Determine the variation in flow properties across normal and oblique shock waves.	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

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

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	The Dynamics and Thermodynamics of Compressible Fluid Flow. Vol I	Shapiro A.H	John Wiley & Sons	1977
2	Fundamental of Compressible flow	S. M. Yahya	New age international Publication	7 th edition,2023
3	Gas Dynamics	E. Rathakrishnan	PHI Learning Pvt. Ltd.	7 th edition,2021

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Modern Compressible Flow: With Historical Perspective.	John D. Anderson	McGraw-Hill, Inc	4 th edition,2021
2	Fundamentals of compressible fluid dynamics	P. Balachandran	PHI Learning Pvt. Ltd.	2006
3	Elements of Gas Dynamics	Liepmann and Roshako	Dover Publications Inc.	2002

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://youtu.be/BYqZPwQPU_4 https://youtu.be/TYqxQS6ZPC4
2	https://youtu.be/C2JIBOmEZ4k https://youtu.be/7EKaOXZrEq4
3	https://youtu.be/3npd-kOS2FQ
4	https://youtu.be/Jrdm7Pwssto https://youtu.be/Llc1_XWPyIQ

SEMESTER S6

INDUSTRIAL TRIBOLOGY

Course Code	PEMET633	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Fluid Mechanics and Machinery	Course Type	Theory

Course Objectives:

1. To provide a comprehensive understanding of the fundamental concepts of tribology.
2. To prepare students to integrate tribological knowledge into the design and analysis of engineering systems.
3. To equip students with the analytical skills necessary to assess and solve tribological problems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Tribology: Definition and Scope, Historical development and significance in engineering. Contact Mechanics: Types of contact: point, line, and surface contacts,Hertzian contact theory,Deformation of solid bodies under load Friction: Laws of friction, Types of friction: static, kinetic, and rolling friction Factors affecting friction. Theories of friction: adhesion, deformation, and plowing.	9
2	Wear: Types of wear: adhesive, abrasive, corrosive, and surface fatigue wear. Surface Topography: Statistical Parameters (Ra,Rz,RMS) Techniques of Surface Examination: Optical Microscopy, Electron Microscopy, Atomic Force Microscopy , Profilometry. Wear measurement techniques: Pin-on-	9

	disk Tester and the Four Ball Tester.	
3	<p>Principles of Lubrication: Hydrodynamic lubrication, Boundary lubrication, Elasto-hydrodynamic lubrication (EHL)</p> <p>Lubrication Regimes: Thick film and thin film lubrication, Mixed lubrication, Stribeck curve and its significance</p> <p>Lubricant Properties and Classification: Physical and chemical properties of lubricants, Types of lubricants: oils, greases, and solid lubricants, Additives and their functions Criteria for selecting lubricants</p>	9
4	<p>Surface Treatments and Coatings: Heat treatments, surface hardening, and nitriding, Coatings: PVD, CVD, thermal spray coatings, and electroplating</p> <p>Tribology in Industries: Tribological challenges in engines, transmissions, and braking systems, Role of tribology in machining, forming, and finishing processes, Tribological issues in tool wear and lubrication in manufacturing</p> <p>Recent Advances and Future Trends: Emerging materials and technologies in tribology, Smart lubricants and self-lubricating materials, Sustainable tribology practices, Micro and Nano Tribology (Applications in MEMS/NEMS devices).</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none">• 2 Questions from each module.• Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none">• Each question carries 9 marks.• Two questions will be given from each module, out of which 1 question should be answered.• Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain fundamental principles of Tribology	K2
CO2	Understand Surface characterisation techniques for tribological investigations	K2
CO3	Explain Wear Measurement Techniques:	K2
CO4	Select and Evaluate Lubricants and Surface Treatments:	K2
CO5	Apply tribological knowledge in industrial applications	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Engineering Tribology	G. W. Stachowiak and A. W. Batchelor	Butterworth-Heinemann,	Second , 2000.
2	Introduction to Tribology	BharathBhushan	Wiley-Blackwell	First , 2013
3	Engineering Tribology	John Williams	Cambridge University Press,	First,2005
4	Tribology: Friction and Wear of Engineering Materials	I. M. Hutchings	Butterworth-Heinemann	Second,2017

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Surface Engineering for Corrosion and Wear Resistance	J.R. Davis	ASM International	First,2001
2	Lubrication and Lubricant Selection: A Practical Guide	A. R. Lansdown	ASME	Third,2003
3	Tribology for Scientists and Engineers	Pradeep L. Menezes, Siddhartha Ghosh, and BijoyBhushan	Springer	First,2013
4	Advanced Tribology: Proceedings of CIST2008 & ITS-IFTtoMM2008	JianbinLuo, YonggangMeng, Tianmin Shao, and Qian Zhao	Springer	2010

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/102/112102014/
2	https://archive.nptel.ac.in/courses/112/102/112102014/
3	https://archive.nptel.ac.in/courses/112/102/112102014/
4	https://nptel.ac.in/courses/113108083

SEMESTER S6

FINITE ELEMENT METHODS

Course Code	PEMET634	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET302 Mechanics of Solids	Course Type	Theory

Course Objectives:

1. To study the basic procedure of FEM and stiffness formulation of simple element using direct method.
2. To study the formulations of shape functions, strain displacement matrix and stress matrix.
3. To study the energy method and Galerkin weight residual formulations.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction FEM, Mathematical Modelling of field problems in Engineering, Governing Equations – Discrete and continuous models, discretization-convergence behavior. General procedure of Finite Element analysis, Types of elements, Formulation of stiffness matrix- one dimensional spring, bar element assembly and solution procedure.	9
2	Types of coordinate system in FEM, coordinate transformation Plane truss stiffness formulation and its assembly. Shape functions, Derivation of shape functions using polynomial of One-Dimensional bar, 2-Dimensional CST and 1- Dimensional beam element. Convergence requirement of shape functions, Pascal triangle. Shape functions using Langrange polynomial.	10
3	Derivation of strain -displacement relation- B matrix- bar, CST and beam element. Potential energy and equilibrium, principle of minimum potential	

	energy, Variational formulation in FEM. Element stiffness-bar, beam and CST element, consistent loads.	9
4	Strong and Weak form, Galerkin's weighted residual FEM formulation; One dimensional axially loaded bar, heat flow in a bar, natural coordinate system, Iso parametric elements, Quadrilateral elements- Serendipity elements Isoparametric formulations, Jacobian matrix, stiffness matrices, Numerical integration: Gaussian quadrature.	10

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p align="center">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p align="center">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To understand the governing equations of various physical phenomena and basic procedure of FEM.	K2
CO2	To apply the coordinate transformation and formulation of shape functions of various element.	K3
CO3	Formulate shape functions and element strain displacement matrix of various element	K4
CO4	Evaluate element stress using energy method and study Galerkin weight residual formulations	K5
CO5	Study the concept of iso parametric elements and analyze iso parametric formulations	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	An introduction to Finite Element Method	J N Reddy	McGrawHill Education	Third Edition, 2009
2	Concept and application of Finite Element method	Robert D Cook	Wiley	Third Edition, 2008
3	Finite Element Analysis,	S SBhavikatti,	New Age Publisher	Third edition,2008
4	A First Course in Finite Elements	Jacob Fish Rensselaer ,Ted Belytschko	John Wiley & Sons, Ltd	Second edition,2007

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Applied Finite Element Analysis	Larry J Segerlind	Johny Wiley and sons	Second Edition,2010
2	Applied Finite element Analysis	G Ramamurthi	I K International Publishing House Pvt. Ltd	Second Edition
3	Fundamentals of Finite Element Methods	David V Hutton	McGrawHillEducation	Third Edition,2009

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://nptel.ac.in/courses/112106135
2	https://nptel.ac.in/courses/112106135
3	https://nptel.ac.in/courses/112106135
4	https://nptel.ac.in/courses/112106135

SEMESTER S6

NON – DESTRUCTIVE TESTING

Course Code	PEMET636	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To comprehend the fundamental ideas, methodologies, tools, applications and constraints of NDT approach.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Visual Inspection: Fundamentals of visual testing, tools, applications and limitations. Vision, lighting, material attributes, environmental factors. Visual perception, direct and indirect methods, mirrors, magnifiers, boroscopes, fibrosopes, closed circuit television, light sources special lighting, a systems, computer enhanced system. Liquid penetrant Testing: properties required for a good penetrants and developers - Types of penetrants and developers. LPI technique/ test procedure interpretation and evaluation of penetrant test indications, false indication and safety precaution required in LPI.	9
2	Magnetic Particle Testing: Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique, central conductor testing, and magnetization using yokes. Direct and indirect method of magnetization, continuous testing of MPI, residual technique of	9

	<p>MPI, system sensitivity, checking devices in MPI.</p> <p>Eddy Current Testing: physics aspects of ECT. Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT, relation between frequency and depth of penetration in ECT. Equipment and accessories, Various application of ECT such as conductivity measurement, hardness measurement, defect detection coating thickness measurement.</p>	
3	<p>Ultrasonic Testing: UT testing methods, contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing techniques, resonance testing, through transmission technique, pulse echo testing technique, instruments used UT, accessories such as transducers, types, frequencies, and sizes commonly used. Reference blocks with artificially created defects, calibration of equipments.</p> <p>Radiography Testing (RT): Electromagnetic radiation sources. Inspection techniques like SWSI, DWSI, DWDI, panoramic exposure, real-time radiography, films used in industrial radiography, types of film, speed of films, qualities of film screens used in radiography, quality of a good radiograph, film processing, interpretation, evaluation of test results, safety aspects required in radiography.</p>	11
4	<p>Advanced NDI Techniques: Principle and Procedure of Digital Signal and image Processing & Digital Image correlation, Acoustic emission Inspection, Thermography, Computed Tomography</p>	7

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Have a basic knowledge of NDT Techniques which enables to carry out various inspections in accordance with the established procedures.	K2
CO2	Familiarize with basic principles of electromagnetic NDT methods	K2
CO3	Apply the principles of signal processing of ultrasonic signals and image processing of radiographic images.	K3
CO4	Have a better knowledge in the field of advanced techniques in NDT	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	-	-	-	-	-	-	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-
CO3	3	1	-	-	-	-	-	-	-	-	-	-
CO4	3	1	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Practical Non- destructive testing	Baldev Raj	Alpha Science International	2008
2	Non - destructive testing	Hull V and V John	McMillan	2012
3	Non Destructive testing Techniques	Ravi Prakash	New Academic Science	2009

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Recent developments in the field of non-destructive testing, safety and material science	Elena Lysenko, Alexander Rogachev, Oldrich Stary	Springer	2022
2	New Technologies in electromagnetic non-destructive Testing	Songling Huang & Shen Wang	Springer	2016
3	Recent Advances in Non - Destructive Inspection	Carosena Meola	Nova Science publishers	2010

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
I to IV	https://archive.nptel.ac.in/courses/113/106/113106070/

SEMESTER S6

INDUSTRIAL SAFETY ENGINEERING

Course Code	PEMET637	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

To provide on concept of safety in industry, principle of accident prevention, major hazards and consequences.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Industrial Safety: Concept of Safety, Goals of safety engineering, Need for safety engineering, definitions of Accident, injury, unsafe actions & Conditions. Accident causing mechanisms, Heinrich's Law of accident prevention. Responsibility of Safety - Society, Govt., Management, Union & employees. Duties of safety officer. Safety Committee - Functions & Scope, Safety Awareness and Training, Safety audit and mock drill.	9
2	Hazard and hazard identification: Hazard and risk, Types of Chemical hazards and its control. Fire safety. Factors contributing towards fire, Classification of Fire and Fire extinguishers. Explosion-Toxic gas release - precautions. Consequence assessment and mitigation measures. – Effect model-vulnerability model Electrical Hazards – controls- Safe limits of amperages, Voltages Safe distance from lines. Means of cutting of power overload and short circuit	9

	<p>protection.</p> <p>Hazard identification and risk assessment: Inventory analysis, Hazard rating of process plants- The Dow Fire and Explosion Hazard Index, Hazard analysis -Preliminary hazard analysis, HAZOP, FMEA.</p>	
3	<p>Occupational Health and Safety: Safety and Health training, Stress and Safety. Ergonomics - Introduction, Advantages. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders. Human factors contributing to accidents.</p> <p>Personal protection in the work environment, Types of PPEs, Respiratory and non-respiratory equipment. Standards related to PPEs. Hearing Conservation Program in Production industries.</p>	9
4	<p>Safety issues in Machines: Machinery safeguard, Principle of machine guarding -types of guards and devices. Safety in machining, welding and cutting.</p> <p>Material Handling-Classification-safety consideration- manual and mechanical handling-Maintenance of common elements-wire rope, chains slings, hooks, clamps.</p> <p>Monitoring Safety Performance: Frequency rate, severity rate, incidence rate Housekeeping, Work permits system. Entry into confined spaces.</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the theories of accident causation and preventive measures of industrial accidents.	K2
CO2	Describe the different types of hazards and apply hazard identification tools.	K3
CO3	Understand the occupational health hazards and human factors contributing to industrial accidents.	K2
CO4	Explain about personal protective equipment, its selection, safety performance & indicators.	K2
CO5	Describe various hazards associated with different machines and mechanical material handling.	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	-	-	2	2	2	-	-	-	-
CO2	2	2	2	-	-	-	-	-	-	-	-	-
CO3	2	2	-	-	-	2	2	2	-	-	-	-
CO4	2	2	2	-	-	-	-	-	-	-	-	-
CO5	2	2	2	-	-	-	-	-	-	-	-	-

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Industrial Safety, Health and Environment management systems	R.K Jain	Khanna Publications	2000
2	Safety Management	Grimaldi and Simonds	AITBS Publishers, New Delhi	2001
3	Occupational Safety and Health Management	Thomas J. Anton	McGraw Hill	1989
4	Safety management System and Documentation training Programme handbook	Paul S V	CBS Publication	2000

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Safety management in Industry	Krishnan, N.V.	Jaico Publishing House, New Delhi	1997
2	Industrial safety	Ronald P. Blake.	Prentice Hall, New Delhi	1973
3	Safety management system	Alan Waring	Chapman & Hall, England	1996
4	Guidelines for Hazard Evaluation Procedures	AIChE/CCPS	Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York	Second edition, 1992

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://nptel.ac.in/courses/110105094
2	https://nptel.ac.in/courses/110105094
3	https://nptel.ac.in/courses/110105094
4	https://nptel.ac.in/courses/110105094

SEMESTER S6

MARKETING MANAGEMENT

Course Code	PEMET638	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. To evaluate the Marketing concepts and ideas.
2. To analyse the consumer behaviour in the market.
3. To interpret the ideas in pricing of products.
4. To identify modern day advertisement and marketing methods.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	INTRODUCTION: Definition of Marketing- Evolution-Marketing concept- Marketing mix- 4 Ps Frame work-Marketing orientation and philosophies.: Types of Markets-Different Market segmentation- Non segmented markets- Benefits- Limitations MARKETING RESEARCH & ENVIRONMENT. Stages in Marketing research- Types of Research Methods- Exploratory- Descriptive- Experimental -Survey Methods Marketing Environment- Micro& Macro environment -Factors affecting- Economic-Technological- political -Competitive Environment-Green Marketing concept.	9
2	CONSUMER BEHAVIOUR:- Consumer Psychology- Choice criteria-	

	order management cycle – Buying situation- Personal and social influence . PRODUCT DECISION: Concept of a Product – Types of Products- Business, Consumer , Service product-.Commodity- Technology and Customised product .New product development- Product idea-Product Life Cycle. Brand- Brand attributes- Building a brand name -strategies of corporate Branding.	9
3	PRICING STRATEGIES: setting the price of a product-pricing policies and constraints-factors influencing pricing decision-Methods of pricing- cost oriented -competitor oriented- marketing oriented pricing -tactics of price adjustment. price wars- price sensitivity CHANNEL DECISION- Nature of Marketing Channels –. Types of Channel flows –Consumer- Industrial-Service channels. Functions of Distribution Channel – Structure and Design of Marketing Channels - Channel co-operation, conflict and competition – Channel Intermediaries- Franchising Retailers and wholesalers-Theory of retailing.	10
4	ADVERTISEMENTS: Advertisements- Identifying audience - Types of Advertisements-Impact of advertisements. Role of Media in advertisements- Advertisement restrictions & legal actions. DIRECT & INTERNET MARKETING: Direct marketing Techniques- Direct mail-Tele marketing- catalogues- direct response. Internet Marketing- Types of Networks- e business practices in post covid era. B2B-B2C-C2C- C2B exchanges.	8

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none">• 2 Questions from each module.• Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none">• Each question carries 9 marks.• Two questions will be given from each module, out of which 1 question should be answered.• Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To familiarise with the basic terms of marketing.	K1
CO2	Evaluate the marketing concepts and ideas	K2
CO3	Identify the consumer concepts in buying	K1
CO4	Understand the method of channelling the product	K1
CO5	Analysis of various pricing strategies in the market	K3
CO6	Analyse the modern day advertising methods	K3
CO7	Understand the digital marketing methods	K1

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	1	1	-	-	-	-	1
CO2	2	-	-	-	-	-	-	-	-	-	-	1
CO3	2	-	-	-	-	1	1	-	-	-	-	1
CO4	1	1	1	1	-	-	-	-	-	-	-	2
CO5	2	1	-	-	-	-	-	-	-	-	-	2
CO6	2	-	-	-	-	-	1	-	-	-	-	1
CO7	2	1	-	-	-	-	-	-	-	-	-	1

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Marketing Management	Phillip Kotler, Kevin Lane Keller	Pearson Publication	15th Edition (2018)
2	Marketing Management	Arun Kumar, N Meenakshi	Vikas Publishing house	2nd Edition (2013)
3	Research for Marketing decisions	Paul E Green, Donald S Tull, Gerald Albaum	PHI learning	5th Edition (2010)
4	Managing Marketing	Noel Capon, Sidharth Shekhar Singh	Wiley Publications	1 ST Edition (2014)

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Marketing Analytics	Wayne L Winston	Wiley publication	2nd Edition 2018
2	Strategic Market Management-Global perspective	David A Aaker, Damien McLoughlin	Wiley Publications	3rd Edition 2016

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/110/104/110104068/
2	https://archive.nptel.ac.in/courses/110/104/110104068/
3	https://archive.nptel.ac.in/courses/110/104/110104068/
4	https://archive.nptel.ac.in/courses/110/104/110104068/

SEMESTER S6
ADVANCED MATERIALS

Course Code	PEMET635	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET205	Course Type	Theory

Course Objectives:

1. Develop the understanding of materials
2. Apply materials science and engineering solutions to enhance existing technology

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Introduction to advanced materials, Advanced materials and alloys, Super alloy: Metallurgy and strengthening mechanisms, Types of super alloy and application.</p> <p>Bulk metallic glasses: Mechanism of formation, properties, and application.</p> <p>High Entropy Alloys (HEA): Thermodynamics, applications, Core effects of HEA, Phase selection in HEA.</p> <p>Self-healing materials: different self-healing processes. Materials for self-healing process.</p>	9
2	<p>Shape-Memory Materials: Shape memory effect and phase transformation effect, Superelasticity or Pseudoelasticity, Shape Memory Polymer (SMP), Thermo-Stimulated SMP, Electric-Stimulated SMP, Light-Stimulated SMP, Shape Memory Ceramic, Shape Memory Hybrids.</p> <p>Piezoelectric Materials: Direct and inverse Piezoelectric Effect, Materials used for piezoresistivity (Ceramics, Polymer and Composites), Single Crystal</p>	9

	<p>Piezoelectric.</p> <p>Smart Fluids: Electro-Rheological Fluids, Magneto -Rheological Fluid, Ferro Fluids, Photo-Rheological fluids, Materials used for ER, MR and PR fluids.</p>	
3	<p>Nanomaterials: Size effect, synthesis and properties of Nanomaterials. Application of Nanomaterials. Carbon based nanomaterials- Graphene, CNT, Carbon dots, Fullerene. Pyrolyzed nanocarbon materials, properties and applications</p> <p>Emerging 2D materials (Hexagonal boron nitride (h-BN), metal chalcogenides, metal oxides, metal halides, metal carbides/nitrides (MXenes), and organic semiconductors (OSCs)), properties and applications.</p> <p>Emerging photovoltaic materials</p>	9
4	<p>Ultralight materials: Aerogels, metallic and ceramic foams Biomaterials: Biocompatibility, Classification of biomaterials and applications. Surface modification of biomaterials-biocompatible coating, surface treatment,</p> <p>Advanced plastic materials, High temperature and conducting plastics, Biodegradable and Biorenewable Polymers/Plastics, Applications</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 = 24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Get introduction to different types of advanced materials	K4
CO2	Understand properties of alloys and self healing materials	K4
CO3	Understand and identify the applications of smart materials	K4
CO4	Learn the application and scope of nano-materials	K4
CO5	Identify the importance of biomaterials	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

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

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Advanced Materials An Introduction to Modern Materials Science	Ajit Behera	Springer	2021

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Biomaterials Principles and Practices	Donald R. Peterson, Joseph D. Bronzino, Joyce Y. Wong	Taylor & Francis	2012
2	Carbon Nanomaterials	Volker Presser, Yury Gogotsi	CRC Press	2006
3	Advanced Materials	Ivan A. Parinov, Shun- Hsyung Chang, Vitaly Yu. Topolov	De Gruyter	2020

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://onlinecourses.nptel.ac.in/noc19_mm13/preview
2	https://onlinecourses.nptel.ac.in/noc19_mm13/preview
3	https://onlinecourses.nptel.ac.in/noc19_mm13/preview
4	https://nptel.ac.in/courses/113104009

SEMESTER S6

THERMAL ENGINEERING

Course Code	PBMET604	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET403 Engineering Thermodynamics	Course Type	Theory

Course Objectives:

1. To become proficient with steam turbines and steam power systems.
2. To comprehend and evaluate the performance of internal combustion engines and examine their combustion processes

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Steam Power Cycle: Simple Rankine cycle, Improvements in Rankine cycles-Reheat and Regenerative cycles – Numerical problems. Steam Boilers: Types of boilers, Fire tube boiler - Cochran boiler, Water tube boiler - Babcock and Wilcox, Boiler Mountings and Accessories. Steam nozzles: -Types of nozzles, Velocity, Effect of friction, nozzle efficiency and its effects - Simple numerical problems, Super saturated flow.	9
2	Steam turbines: Classification, compounding of turbines-pressure velocity variation. Velocity diagrams, work done, efficiency, Condition for maximum efficiency (Derivation not required). Graphical Method for solving velocity triangle problems on impulse and reaction turbines. Multistage turbines -Condition line, stage efficiency, reheat factor and degree of reaction. Governing of turbines – Centrifugal governing and Nozzle governing.	9

3	<p>Fundamentals of IC Engines: Air standard cycles, their analysis, and applications - Otto cycle, Diesel cycle, Dual cycle, Atkinson cycle (No numerical problems and derivations)</p> <p>Reciprocating type SI and CI engines: Ideal and Actual cycle for IC engines– Deviation from ideal cycle and associated factors. Super charging, and turbo charging.</p> <p>Engine Testing and Performance of SI and CI engines: Torque, Engine power- BHP, IHP, Efficiencies of IC engines, Specific fuel consumption, Mean effective pressure. Morse test, Heat balance test and Retardation test – Simple Numerical problems.</p>	9
4	<p>Combustion in IC Engines: Fuels for IC engines, Ignition limits, air-fuel ratio, equivalence ratio.</p> <p>S.I. engines: Stages of combustion in S.I. Engines, Ignition lag, Auto ignition and Detonation, Effects of engine variables on detonation and Octane rating of fuels.</p> <p>C.I. Engines: Stages of combustion in C.I engines, Delay period, variables affecting delay period; knocking, Cetane rating of fuels.</p> <p>Major pollutants from S.I. and C.I. Engines, Measurement of exhaust emissions, Emission Control techniques – Catalytic convertors, Particulate traps Thermal reactor, Exhaust Gas Recirculation</p>	9

Suggestion on Project Topics

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks (8x2 =16 marks) 	<ul style="list-style-type: none"> • 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. (4x6 = 24 marks) 	40

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply the basic thermodynamic principles and analyse the operation of steam power cycles	K4
CO2	Analyse the performance of steam turbines and identify methods to improve their efficiency.	K3
CO3	Identify the performance parameters of IC engines and evaluate their performance.	K3
CO4	Explain the combustion phenomenon and pollution in IC engines.	K2
CO5	Conduct case studies, carry out simulation/testing, and prototyping.	K6

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

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

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Thermal Engineering	Rudra Moorthy	McGraw Hill Education India	2003
2	Thermal Engineering	R.K Rajput	Laxmi publications	2010
3	Fundamentals of IC engines	V. Ganesan	Tata McGraw-Hill	2002
4	Fundamentals of IC engines	H N Gupta	PHI	Second Edition, 2018
5	Internal Combustion Engines	V Sajith and Shijo Thomas	Oxford University Press	2017

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	I.C engine fundamentals	J.B.Heywood	McGraw-Hill	2011
2	Thermal Engineering	Mahesh Rathore	McGraw Hill Education India	2010

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://nptelvideos.com/video.php?id=1181
2	https://nptelvideos.com/video.php?id=1181
3	https://archive.nptel.ac.in/courses/112/103/112103262/
4	https://archive.nptel.ac.in/courses/112/103/112103262/

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	Practical	Presentation
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		30

1. Project Planning and Proposal (5 Marks)

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. Contribution in Progress Presentation and Question Answer Sessions (4 Marks)

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. Involvement in the Project Work and Team Work (3 Marks)

- Active participation and individual contribution
- Teamwork and collaboration

4. Execution and Implementation (10 Marks)

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

5. Final Presentation (5 Marks)

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

6. Project Quality, Innovation, and Creativity (3 Marks)

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches

SEMESTER S6

INTRODUCTION TO BUSINESS ANALYTICS

Course Code	OEMET611	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Basic Knowledge of Statistics	Course Type	Theory – Open elective

Course Objectives:

1. Understand the Importance of Analytics in Decision making and Problem solving.
2. Understand the basic concepts in different levels of Analytics and how it is used in data-driven decision making.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Business Analytics: Why Analytics- Business Analytics: The Science of Data Driven Decision Making - Components of Business Analytics- Levels of Analytics – Descriptive Analytics, Predictive Analytics and Prescriptive Analytics- Framework for Data Driven Decision Making- Challenges in Data Driven Decision Making and Future. Introduction to Big data Analytics –Characteristics- Sources of Big Data.	9
2	Data: Definition and its Importance- How Data Add Value to the Business- Data Analytics vs Data Analysis Introduction to Descriptive Analytics: Data Types - Structured and Unstructured data - Types of Data Measurement Scales. Measures of Central Tendency: Arithmetic Mean-Mean of Grouped Data -Weighted Mean – Median- Median of Grouped Data- Mode- Mode of Grouped Data- Percentiles.	9

	<p>Measures of Dispersion: Range - Inter Quartile Range - Standard Deviation - Variance and Coefficient of Variation.</p> <p>Measures of Shape- Skewness and Kurtosis.</p>	
3	<p>Data Visualization: Histogram- Bar Chart-Pie Chart-Scatter Plot-Coxcomb Chart-Box and Whisker Plot.</p> <p>Correlation Analysis: Pearson Correlation Coefficient-Spearman Rank Correlation.</p> <p>Predictive Analytics: Simple Linear Regression-Simple Linear Regression Model-Least Squares Method -Coefficient of Determination -Model Assumptions.</p>	9
4	<p>Prescriptive Analytics: Introduction</p> <p>Business Performance Management: Business Performance Management cycle-Performance management system-Key Performance Indicators.</p> <p>Analytics in Business support functions: Sales and Marketing - Human Resources-Financial Analytics-Production and Operations Analytics.</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. Total of 8 Questions, each carrying 3 marks <p align="center">(8x3 =24marks)</p>	<ul style="list-style-type: none"> Each question carries 9 marks. Two questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. <p align="center">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of business analytics and how it is becoming competitive strategy for many organisations.	K2
CO2	Understand the Importance of analytics in decision making and problem solving.	K2
CO3	Understand the application of descriptive analytics in decision making.	K2
CO4	Learn data visualization and various types of visual charts.	K2
CO5	Apply simple linear regression model in predictive analytics problems.	K3
CO6	Understand the basic concepts in prescriptive analytics.	K2
CO7	Understand the essence of business performance management and analytics in business support functions.	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	2	-	-	-	-	2	-	-	-
CO2	2	2	2	3	3	-	-	-	-	-	-	-
CO3	2	2	3	3	3	-	-	-	-	-	-	-
CO4	2	-	-	-	-	-	-	-	-	-	-	-
CO5	3	2	3	3	3	-	-	-	-	-	-	-
CO6	2	2	2	1	2	-	-	-	-	-	-	-
CO7	-	-	-	-	-	2	-	2	2	3	2	-

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Business Analytics-The Science of Data Driven Decision Making	U Dinesh Kumar	Wiley	First Edition:2017
2	Fundamentals of Business Analytics	R. N. Prasad & Seema Acharya	Wiley	Second Edition:2016
3	Business Intelligence. Analytics and Data Science: A Managerial Perspective	R. Sharda, D. Delen & E. Turban	Pearson	Fourth Edition:2018

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Data Analytics	A. Maheshwari	McGraw Hill Education	First Edition:2017
2	Business Analytics for Managers: Taking Business Intelligence Beyond Reporting	Gert H. N. Laursen & Jesper Thorlund	Wiley	First Edition:2017
3	Business Analytics	J. R. Evans	Pearson	Third Edition:2019

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://youtu.be/YZf5q-ICf8Y
2	https://youtu.be/1MiT06JFNo4 and https://youtu.be/6lQn1hdG43o
3	https://youtu.be/eY55ocm-VgM and https://youtu.be/xXDoZLVjfs

SEMESTER S6

QUANTITATIVE TECHNIQUES FOR ENGINEERS

Course Code	OEMET612	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3: 0: 0: 0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory – Open elective

Course Objectives:

1. This course will equip the student with the expertise to mathematically model real life optimization problems and subsequently educate the student to solve these models with the help of the available methods. The mathematical concepts and models deal with solving engineering problems using minimum available resources.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Quantitative Techniques: Basics of Operations Research – Applications - Linear Programming - Problem Formulation, Graphical method, Simplex method, Big-M Method. Decision Making: Decision under certainty, risk and uncertainty: Decision trees, EMV method, EOL method, MaxiMin criterion, MiniMax criterion.	9
2	Transportation Problem: Mathematical Formulation, Balanced and unbalanced problems, Initial Basic Feasible Solution, North West Corner method, Least Cost method, Vogel’s Approximation Method, Optimality test by MODI method, Assignment problem, Hungarian method. Sequencing Problem: Basic terminologies, Processing of n Jobs through 2, 3 and m machines.	9

3	<p>Network analysis – Basic terms – Network construction, time analysis, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT).</p> <p>Game Theory: Games with saddle points, Games without saddle points – 2 x 2 games, Graphical method for m x 2 and 2 x n games</p>	9
4	<p>Queuing theory: Scope, terminology, classification Importance and applications, Performance Measures in Queuing Systems, Single-server exponential arrival and service times. Multi - server problems.</p> <p>Simulation: Monte Carlo simulation – Queuing simulation model- Generation of random numbers</p>	9

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To formulate and solve linear programming and transportation problems	K4
CO2	To apply decision theory under various conditions of certainty, risk, and uncertainty.	K3
CO3	To sequence and schedule jobs and projects	K3
CO4	To solve Game Theory problems	K3
CO5	To solve problems using classical queuing theory models	K3

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

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

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Operations Research	Paneerselvam R.	PHI	Third edition, 2023
2	Operations Research	Taha	Pearson	Tenth edition, 2019

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Introduction to Operations Research	F. S. Hillier and G. J. Lieberman	McGraw Hill	Tenth edition, 2017
2	Discrete Event System Simulation	Banks, Carson, Nelson and Nicol	Pearson	Fifth edition, 2013

SEMESTER S6

AUTOMOTIVE TECHNOLOGY

Course Code	OEMET613	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory – Open elective

Course Objectives:

1. To understand the fundamental principles and technologies of automotive propulsion systems, including electric, hybrid, and internal combustion engines, along with their classifications and basic dynamics.
2. To understand automotive components and systems such as power plants, fuel supply, ignition, transmission, chassis, steering, braking, suspension and Electrical/Electronic architecture.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction: History of automobiles: Electric, Hybrid and Internal Combustion Engines (ICE) vehicles – classification of automobile L, M and N category. Sub division according to body style (hatchback to station wagon). Basic vehicle dynamics: Rolling, Air and Grade resistance, Power and Torque for propulsion (basic equations). Different ICEs – SI & CI, Single and multicylinder with arrangements, Bi fuel & dual fuel, latest technologies in ICEs – Flex fuel vehicles, H ₂ -ICE, Hybrid types – Mild & strong hybrids, series, parallel, and series parallel types.	9

2	<p>Power plant: Components in an IC engine – head, block & sump, cylinder, piston, piston pin, crank, connecting rod, valve train and types, combustion process – A/F ratio, self-ignition temperature, Octane and cetane number.</p> <p>Fuel, Air and ignition systems: Carburetors(simple), MPFI, CRDI & GDI systems with components (line diagram). Working of solenoid and piezo injectors. Naturally aspirated and forced induction systems (turbo and super charger). Spark ignition systems –components, ignition timing, Single coil ignition system & coil over plug ignitions system.</p>	9
3	<p>Lubrication, Cooling and exhaust system: Lubrication system – basic circuitry, oil grade and viscosity. Cooling system – basic circuit including thermostat valve. Exhaust system – 3-way catalytic converter, DPF and SCR basics.</p> <p>Transmission & Chassis: Gear ratio, manual transmission: synchromesh, Automated and Automatic transmission basics, Friction and Fluid clutches basics. Different types chassis – tubular to integrated, duties of a chassis.</p>	9
4	<p>Steering, Braking and Suspension: Working of manual, electric and hydraulic steering system. Working of brake system – hydraulic, pneumatic and ABS. Suspension system – rigid & independent, coil & leaf, shock absorber basics.</p> <p>E & E architecture –ECUs, sensors and actuators other than ECM, distributed and zonal electrical architecture. Basics of communication protocols – CAN, LIN and ethernet. Electric vehicle components and energy flow, On-board diagnostic basics – DTC code, basics of ADAS – sensors, levels of automation, examples – LDWS to Lane change assist, Adaptive cruise control, Automatic emergency braking, Driver monitoring system, Autonomous Vehicles.</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p align="center">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p align="center">(4x9 = 36 marks)</p>	60

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Automobile Engineering, Vol.1 & Vol.2	Kirpal Singh	Standard Publishers	13 th edition,2020.
2	A Textbook of Automobile Engineering	S K Gupta	S Chand	January 2020
3	Fundamentals of motor vehicle technology.	Hillier and Peter Coobes	New Age International Private Limited	6th edition (1 January 2006)
4	Vehicle and engine technology	Heinz Heisler	Society of Automotive Engineers	2nd edition (1 September 1998)
5	Automobile mechanical and electrical systems	Tom Denton & <u>Hayley Pells</u>	Routledge Publishers	3 rd edition, 2022
6	Automobile Electrical and Electronic systems	Tom Denton	Routledge Publishers	5 th edition, 2018

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Automotive Mechanics	Heitner J	East-West Press	2 nd edition, 1999
2	Automobile Engineering	Jain K.K. and Asthana R. B	Tata McGraw Hill	New Delhi, 2002
3	Electric and Hybrid Vehicles	Tom Denton	Routledge Publishers	2nd edition, 2020
4	Fundamentals of modern vehicle technology	V.A.W. Hillier	Butterworth-Heinemann	2nd edition,1998

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/107/106/107106088/
2	https://archive.nptel.ac.in/courses/107/106/107106088/
3	https://archive.nptel.ac.in/courses/107/106/107106088/
4	https://archive.nptel.ac.in/courses/107/106/107106088/

SEMESTER S6

RENEWABLE ENERGY ENGINEERING

Course Code	OEMET614	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory – Open elective

Course Objectives:

1. The course is aimed at imparting basic knowledge on the different types of renewable energy resources and utilization of these energy effectively so as to minimize the consumption of non-renewable energy to a greater extent.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>The Energy Scenario- Commercial energy sources -World's production and reserves- India' Production and reserves.</p> <p>Solar Energy collectors: Solar thermal collectors -Flat plate collectors –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – Solar Air Heaters. Solar thermal electric power generation -Thermal Energy storage, sensible heat storage, latent heat storage , Thermo chemical storage , photovoltaic system for power generation , Solar pond -Solar Cells-Types of solar cells , principle of working and performance characteristics, Production process- Block diagram only Applications- Solar space heating and cooling of buildings, solar pumping, solar cooker, solar still, solar drier, solar refrigeration and air-conditioning, heliostat, solar furnace.</p>	11

2	Wind Energy- classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, tip speed ratio, solidity of turbine' power control strategies, Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of WECS	7
3	Ocean Energy – Devices for Wave Energy conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Geothermal energy: Introduction, hot dry rock resources, magma resources, vapour and liquid dominated systems, binary cycle, advantages and disadvantages	10
4	Bio Mass Energy- Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel, Biogas production from waste biomass, factors affecting biogas generation Bio Gas -KVIC and Janata model. Hydrogen Energy – various routes for production of Hydrogen energy.	8

**Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none">• 2 Questions from each module.• Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none">• Each question carries 9 marks.• Two questions will be given from each module, out of which 1 question should be answered.• Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain solar energy collectors, storages, solar cell characteristics and applications	K2
CO2	Explain the different types of wind power machines and control strategies of wind turbines	K2
CO3	Explain the ocean energy and conversion devices and different Geothermal sources	K2
CO4	Explain biomass energy conversion devices. Calculate the Net Present value and payback period	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Solar Energy: Principles of Thermal Collection and Storage	S P Sukhatme , J K Nayak	Mc Graw Hill	2015
2	Fundamentals of renewable energy sources	Tiwari G N, Ghosal M K	Alpha Science International Ltd	2007
3	Sustainable Energy Choosing among options	Jefferson W Tester et.al	PHI	2006

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Renewable energy resources and emerging technologies	D.P. Kothari	Prentice Hall of India Pvt. Ltd	2011
2	Fundamentals and Applications of Renewable Energy	Mehmet KanoğluYunus A. Çengel John M. Cimbala	Mc Graw Hill	2019

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1 to 4	https://nptel.ac.in/courses/103103206

SEMESTER S6

QUALITY ENGINEERING AND MANAGEMENT

Course Code	OEMET615	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory – Open Elective

Course Objectives:

1. To impart knowledge on principles and practices of quality engineering and management.
2. To enable use of various tools and techniques for continuous quality improvement.
3. To provide ideas on implementation of quality standards

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Quality Management - Definitions of quality, Dimensions of Quality, Concepts of Product and Service Quality, Evolution of Quality Management, quality control, quality assurance, quality planning, quality management, Total Quality Management (TQM)-the TQM axioms - Consequences of total quality- Barriers to TQM, Deming approach, Juran's quality trilogy, Crosby's fourteen steps for quality improvement, Quality circles.	9
2	Human dimensions of TQM – Top management commitment- Leadership for TQM- Change management- resources for quality activities - Training for quality –Employee involvement, motivation, empowerment- teamwork- self managing teams - Role of the quality director-Quality System: ISO 9000 family of standards. Quality auditing- types and benefits.	9
3	Tools and Techniques in TQM: Affinity diagram -brainstorming - cause and effect analysis - process flow chart – check sheets- Scatter diagram -	9

	Pareto chart- Histogram. Quality control and Inspection, Fundamentals of statistics, accuracy and precision, causes of variation in quality, Statistical Process Control, control charts, \bar{x} and R chart problems, process capability, Acceptance sampling.	
4	Strategic Quality Management: Integrating quality into strategic management - obstacles to achieving successful strategic quality management-Cost of Quality-Customer satisfaction. Quality Function Deployment (QFD), Failure Mode and Effect Analysis, Analysis of Variance (ANOVA), Design and Analysis of Experiments (DOE), Concepts of 5S, Kaizen, Six Sigma, Total Productive Maintenance. Reliability Engineering - types and causes of failures - Bath tub curve - System reliability - Life testing.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> Each question carries 9 marks. Two questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop knowledge of quality management and contributions of quality gurus.	K2
CO2	Identify various human dimensions of TQM	K2
CO3	Implement different tools and techniques in TQM	K3
CO4	Implement different statistical quality control techniques	K3
CO5	Demonstrate knowledge of the underlying principles of strategic quality management	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

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

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Total Quality Management(TQM)	B esterfield D. H. , BesterfieldC, Besterfield G. H., Besterfield M, U. Hemant, U.Rashmi	Pearson Education	Fifth Edition, 2018
2	Total Quality Management	SubburajRamasamy	Tata McGraw Hill Education	First Edition, 2017
3	Introduction to Statistical Quality Control	D. C. Montgomery	John Wiley & Sons	Third Edition
4	Fundamentals of Quality Control and Improvement	Mitra A.	PHI	Second Edition, 1998

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Design and Analysis of Experiments	D. C. Montgomery	John Wiley & Sons	6thEdition ,2004
2	Quality Planning and Analysis - From Product Development through Use	Juran J M and Gryna, F M	Tata McGraw Hill Publishing Limited, New Delhi	Third Edition, 2004
3	Quality is Free	Crosby P B	McGraw Hill	New York, 1979

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://nptel.ac.in/courses/110105088
2	https://nptel.ac.in/courses/110101010
3	https://nptel.ac.in/courses/110101010
4	https://nptel.ac.in/courses/110101010

SEMESTER S6
ADDITIVE MANUFACTURING

Course Code	OEMET616	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory – Open elective

Course Objectives:

1. To demonstrate appropriate level of understanding on principles of additive manufacturing
2. To understand the different additive manufacturing technologies.
3. To choose appropriate materials for additive manufacturing processes
4. To design prototypes by identifying suitable process with optimum process parameters

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Introduction to Additive Manufacturing (AM) –Basic principle of AM- Procedure of product development in AM process chain. Classification of additive manufacturing processes, Basic concept, Digitization techniques, Benefits and challenges in AM.</p> <p>Data processing for AM- CAD model preparation, Part orientation and support generation, Slicing methods, Tool path generation, STL Formats. Demonstration of slicing software packages.</p>	8
2	<p>Common AM technologies: Principle, materials, process parameters, advantages and applications of: Stereo Lithography (SLA), Digital Light Processing (DLP), Continuous Liquid Interface Production (CLIP), Laminated Object Manufacturing (LOM), Ultrasonic AM (UAM), 3D printing, Binder Jetting, Material Jetting, Fused Deposition Modelling</p>	10

	(FDM), Direct Ink Writing (DIW).	
3	Common AM technologies: Principle, materials, process parameters, advantages and applications of: Selective Laser Sintering (SLS), Selection Laser Melting (SLM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing (WAAM), Laser Engineering Net Shaping (LENS).	10
4	Design for AM (DFAM) AM unique capabilities, DFAM concepts and objectives, Design freedom and synthesis methods. Applications for AM Applications: Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc.	8

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the concept of AM from conventional manufacturing systems.	K2
CO2	Understand the data processing techniques in AM process	K2
CO3	Understand the principles of AM processes.	K2
CO4	Understand the application of AM in industries	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

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

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing.	Gibson I D. W. Rosen I and B. Stucker	Springer	Second Edition, 2015
2	Rapid prototyping: Principles and applications	Chua, C.K., Leong K.F. and Lim C.S.	World Scientific Publishers	Third edition, 2010.

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Rapid Manufacturing The Technologies and Applications of Rapid Prototyping and Rapid Tooling	D.T. Pham and S.S. Dimov	Springer London Ltd	Softcover reprint of the original 1st ed. 2001, 2011
2	Additive Manufacturing: Principles, technologies and Application	C.P. Paul , A.N. Jinoop	McGraw Hill	First Edition, 2021
3	Additive Manufacturing Technologies	S. Shiva , Anuj K. Shukla	Wiley	First Edition, 2024
4	Additive Manufacturing: Fundamentals and Advancements	Manu Srivastava, Sandeep Rathee, Sachin Maheshwari	CRC Press	First Edition, 2019

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1 - 4	NOC: Fundamentals of Additive Manufacturing Technologies, IIT Guwahati by Prof. Sajan Kapil Link: https://nptel.ac.in/courses/112103306

SEMESTER S6

SOLAR ENERGY CONSERVATION SYSTEMS

Course Code	OEMET617	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	OEMET 617	Course Type	Theory – Open elective

Course Objectives:

1. To equip students with a thorough understanding of solar radiation, the sun-earth relationship, and the atmosphere's impact, and to provide detailed knowledge of different solar collectors, their thermal analysis, tracking mechanisms, and storage solutions.
2. To enable students to understand PV systems' principles and performance, including design and components of standalone and grid-connected systems, and to introduce methods of economic evaluation of solar energy technologies, such as cost analysis, payback period calculation, and financial feasibility in the context of energy policy.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction: Energy Scenario: India and world, Basic concepts related to solar radiation, the sun, spectral distribution, sun- earth relationship, extraterrestrial radiation, revolution of earth, seasons, position of sun in the sky, position of sun with respect to the centre of the earth. Role of atmosphere on solar radiation, air mass, terrestrial spectrum, prediction of solar radiation. Sign conventions, angle of incidence on a tilted plane, shading, sun-path diagram, overhangs, parallel rows of solar collectors. Diffuse and direct radiation. Solar energy measuring instruments.	9

2	Solar collectors: Flat plate collector, thermal analysis, heat removal factor. Overview of other thermal collectors. Concentrating collectors, theoretical limit, classifications of concentrators. Parabolic trough collector, thermal analysis, compound parabolic concentrators, Linear Fresnel Reflector, parabolic dish collector, central receiver tower. Tracking of solar concentrators. Solar ponds. Storage of heat in solar thermal power plants, storage media and heat transfer fluids.	9
3	Non-thermal routes for solar energy conversion, Basics of photovoltaic effect, Fundamentals of PV: Principles and performance analysis, Photovoltaic materials, Modules, Array, Maximum Power Point Tracking (MPPT) etc.; standalone PV system: Components and design of standalone system, fundamentals of battery system; grid connected PV system: components and design of grid connected PV systems.	9
4	Methods of fixing power tariff - Simple Methods to Calculate the Plant Economy - Life Cycle Cost - Payback Period – Relevance of financial and economic feasibility evaluation of energy technologies and systems, Energy-economy interaction, Energy Policy related acts and regulation. Economic Analysis for the Selection of Alternative Decisions and the future of the Power Plants.	9

**Course Assessment Method
(CIE: 40marks, ESE: 60 marks)**

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none"> Each question carries 9 marks. Two questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic concepts of solar radiation, the sun-earth relationship, and the effects of the atmosphere on solar energy.	K2
CO2	Able to recall the various types of solar collectors and their theoretical principles, including flat plate collectors and concentrating collectors.	K1
CO3	Apply thermal analysis techniques to different solar collectors and implement design principles for both standalone and grid-connected PV systems.	K3
CO4	Understand the methods for calculating plant economy, including life cycle cost, payback period, and the relevance of economic feasibility evaluations for energy technologies.	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	3	-	-	-	-	-	-
CO2	3	2	-	-	-	2	-	-	-	-	-	-
CO3	3	2	-	-	-	2	-	-	-	-	-	-
CO4	3	2	-	-	-	2	-	-	-	-	-	-

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Solar Energy	S P Sukhatme	McGraw Hill Education (India) Private Limited	Fourth edition (1 January 2017)
2	Principles of Solar Engineering	D. Yogi Goswami, Frank Kreith, and Jan F. Kreider	CRC Press	3rd Edition (2015)
3	Handbook of Solar Energy: Theory, Analysis and Applications	G. N. Tiwari	Publisher Springer	1st ed. 2016
4	Photovoltaic Systems Engineering	Roger A. Messenger and Jerry Ventre	CRC Press	4th Edition (2012)

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Renewable Energy: Power for a Sustainable Future	Godfrey Boyle	Oxford University Press	3rd Edition (2012)
2	Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers	Chetan Singh Solanki	PHI Learning Pvt. Ltd.	1st Edition (2013)
3	Handbook of Photovoltaic Science and Engineering	Antonio Luque and Steven Hegedus	John Wiley & Sons	2nd Edition (2011)
4	Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy - Designing and Installing Solar Photovoltaic Systems	Michael Boxwell	Greenstream Publishing	2020 Edition

Video Links (NPTEL, SWAYAM...)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/104/112104300/
2	https://archive.nptel.ac.in/courses/112/104/112104300/
3	https://archive.nptel.ac.in/courses/115/103/115103123/
4	https://archive.nptel.ac.in/courses/115/103/115103123/

SEMESTER S6

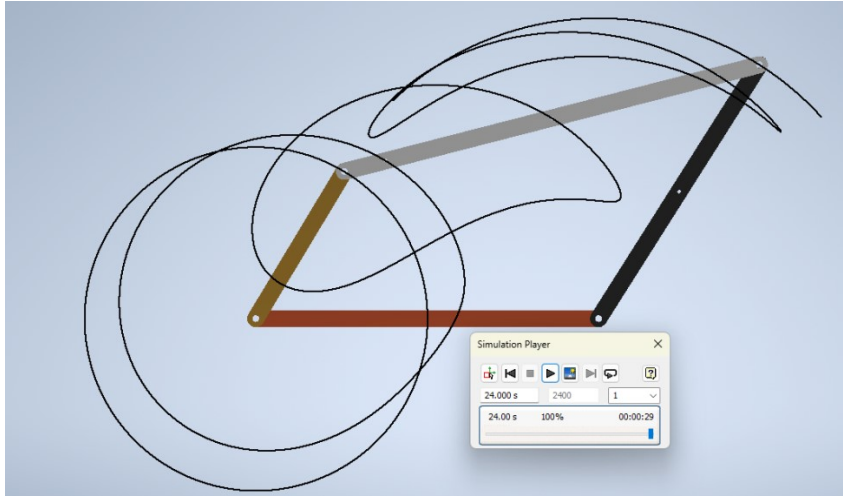
COMPUTER AIDED DESIGN AND ANALYSIS LAB

Course Code	PCMEL607	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Computer Aided Machine Drawing (Course code - PCMEL307)	Course Type	Lab

Course Objectives:

1. Teach students to design and simulate mechanical systems using CAD and FEA software. This includes creating mechanisms like the Whitworth quick return and four-bar linkage, and analyzing structural elements such as bars and trusses.
2. Enable students to perform dynamic simulations and analyze mechanical systems under various loads. This includes studying mechanism kinematics, fatigue, and heat transfer in steady-state and transient conditions.
3. Introduce students to fluid dynamics principles and computational tools for analyzing fluid flow. This includes performing flow analysis on airfoils and improving designs by analyzing flow separations and recirculation zones.

Expt. No.	Experiments
1	<p>Perform a dynamic simulation of a four-bar mechanism.</p> <p>Example Problem Description.</p> <p>Perform a dynamic simulation of a four-bar mechanism using dynamic simulation. The dimensions of the mechanism are as follows: Crank = 100 mm, Coupler = 275 mm, Follower = 150 mm, and Fixed Link = 200 mm. Your objectives are to find the coupler curve at the center point of the coupler, 100 mm towards the crank, and 100 mm towards the follower. Additionally, determine the velocity and acceleration curves of the follower with respect to the fixed link, and specifically find the acceleration and velocity of the</p>

	<p>follower at crank angles of 30°, 60°, and 90°. Begin by modeling the four-bar mechanism, setting up the simulation with appropriate joints, and running the simulation over a complete cycle of the crank. Trace and document the specified coupler curves, plot the velocity and acceleration curves of the follower, and tabulate the velocity and acceleration values at the specified crank angles. Submit a comprehensive report including the 3D model, plots, and a brief discussion on the findings.</p> 
<p>2</p>	<p>Design and Simulation of a Whitworth Quick Return Mechanism</p> <p>Design and simulate a Whitworth quick return mechanism with a specified quick return ratio. Analyze and plot the Coriolis component of acceleration, as well as the position of the slider in the slotted lever, acceleration and position of the tool ram throughout the mechanism's cycle.</p>
<p>3</p>	<p>Perform a structural analysis of an axial bar with varying cross-sectional areas under axial load using FEA software to determine the stress distribution, strain distribution, and total deformation.</p> <p>Example Problem Description:</p> <p>An axial bar of length $L=1\text{m}$ is subjected to an axial tensile load $P=10\text{kN}$. The bar has three different cross-sectional areas along its length: Section 1: From $x=0$ to 0.3m, the cross-sectional area is $A_1 = 50\text{mm}^2$, Section 2: From $x=0.3\text{m}$ to $x=0.7\text{m}$, the cross-sectional area is $A_2 = 75\text{mm}^2$, Section 3: From $x=0.7\text{m}$ to $x=1.0\text{m}$, the cross-sectional area is $A_3 = 100\text{mm}^2$. The bar is fixed at the end with the smallest cross-sectional area (Section 1).</p>
<p>4</p>	<p>Perform a structural analysis of a truss using FEA software to determine the force in each member, identify if the members are in tension or compression, and calculate the</p>

support reactions.

Example Problem Description:

Analyze the given truss structure.

The cross-sectional area of each truss member is 0.01m^2 , the material of the truss members is steel with a Young's Modulus $E = 2.1 \times 10^5 \text{ MPa}$.

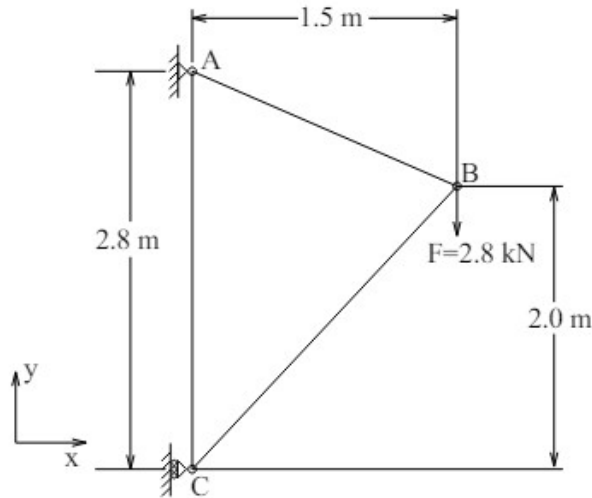


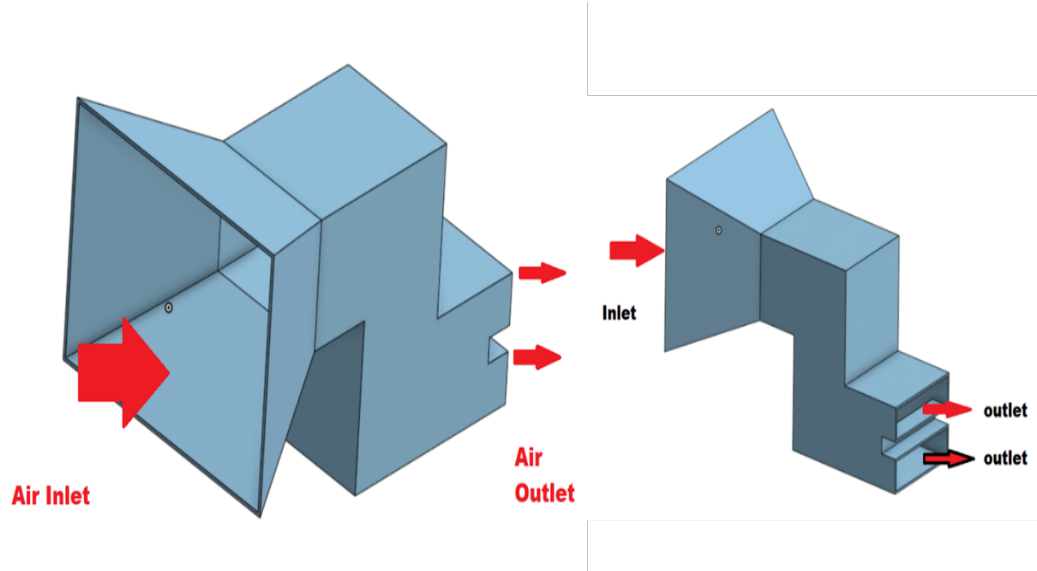
Figure 1: Geometry of the truss.

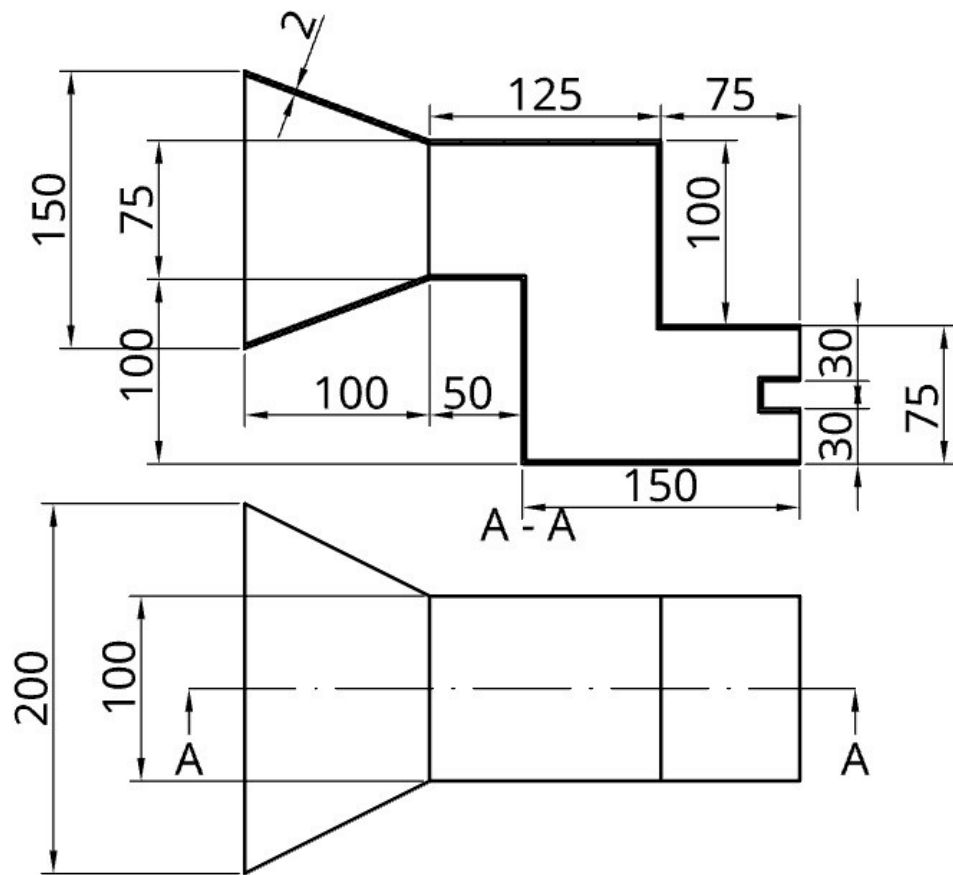
5	Perform the structural analysis of a thin plate (plane stress case) subjected to in plane loads
6	Perform the modal analysis of a cantilever beam
7	Perform the harmonic analysis of a cantilever beam
8	<p>Perform an Eigen-buckling analysis using FEA software.</p> <p>Example Problem Description:</p> <p>Conduct an Eigenbuckling Analysis of a column with I-section using a FEM software to determine the shape numbers and load multipliers for the column. Compare the results obtained with Euler's critical buckling load formula. Additionally, provide the following results: the critical buckling load, the mode shapes, the corresponding displacements, and the stress distribution for each mode.</p>
9	<p>Perform a fatigue analysis using FEA software.</p> <p>Example Problem Description:</p> <p>Perform a fatigue analysis on a Formula SAE hub subjected to a torque of 300 N-m and a dead load of 700 N per wheel. Determine the number of cycles to fatigue failure for the</p>

	hub under these specified loading conditions.
10	<p>Solve a steady-state heat conduction problem using FEA software to determine the temperature distribution within a solid material.</p> <p>Example Problem Description:</p> <p>Consider a rectangular solid plate with dimensions $L = 200$ mm (length), $W = 100$ mm (width), and $t = 10$ mm (thickness). Material Properties given, Thermal conductivity, $k = 50$ W /mK, Density, $\rho = 7800$ kg/m³, Specific heat capacity, $C = 500$ J/kgK.</p> <p>Boundary Conditions:</p> <p>Left edge ($x = 0$ mm): Maintained at a constant temperature $T_1 = 100$ C.</p> <p>Right edge ($x = 200$ mm): Maintained at a constant temperature $T_2 = 50$ C.</p> <p>Top and bottom surfaces ($y = 0$ mm and $y = 100$ mm): Insulated (no heat flux).</p> <p>Front and back surfaces ($z = 0$ mm and $z = 10$ mm): Insulated (no heat flux).</p>
11	<p>Perform a transient heat transfer analysis of a solid fin subjected to natural convection using FEA software to determine the temperature distribution and heat transfer over time.</p> <p>Example Problem Description:</p> <p>Consider a rectangular solid fin made of aluminum with dimensions: length $L = 100$ mm, width $W = 50$ mm, and thickness $t = 5$ mm. The fin is made of aluminum, having a thermal conductivity of $k = 237$ W /mK, density of $\rho = 2700$ kg/m³, and a specific heat capacity of $C = 900$ J/kgK.</p> <p>Initially, the fin is at a uniform temperature of $T_o = 25^\circ\text{C}$. One end of the fin ($x = 0$ mm) is subjected to a constant heat flux of $q = 2000$ W /m², while the surrounding air temperature is $T_{\text{sur}} = 25^\circ\text{C}$ with a convective heat transfer coefficient $h = 10$ W/m² K on all other surfaces. Perform a transient thermal analysis for a duration of $t = 3600$ s (1 hour) with appropriate time steps. The analysis aims to determine the temperature distribution and heat transfer in the fin at various time intervals, including contour plots showing the temperature distribution at different intervals and values of temperature at key points, the base (near 0 mm), the tip ($x = 100$ mm), and the midpoint ($x = 50$ mm). The results should include the total heat transfer rate from the fin to the surrounding air and heat flux distribution plots at the specified time intervals.</p>
12	Perform the 2D flow analysis of an airfoil

Perform a flow analysis to improve the design of an air intake manifold for a pneumatic device by analyzing flow separations and recirculation zones using flow analysis software

13





- Out of 12 exercises, 8 should be given as exercises in the lab sessions. The rest of the exercises are optional

Course Assessment Method (CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- *Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.*
- *Endorsement by External Examiner: The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply CAD and FEA tools to design and simulate mechanical systems. .	K3
CO2	Perform dynamic simulations of mechanical systems and analyze their kinematic behavior	K4
CO3	Conduct thermal and stress analysis on mechanical components under different loading conditions.	K5
CO4	Design optimized mechanical components and airflow systems using Computational Fluid Dynamics (CFD) software.	K6

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

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

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Engineering Design with SolidWorks 2019	David C. Planchard and Marie P. Planchard	SDC Publication	
2	Creo Parametric 6.0 for Engineers and Designers	Prof. Sham Tickoo	BPB Publications	
3	Finite Element Analysis: Theory and Application with ANSYS	Saeed Moaveni	Pearson	
4	Fundamentals of Heat and Mass Transfer	Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, and David P. DeWitt	John Wiley & Sons	
5	Introduction to Computational Fluid Dynamics	Anil W Date	Cambridge University Press	
6	Manuals of software such as CatiaV and UG NX		Respective OEM	

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.

- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S6

THERMAL ENGINEERING LAB-2

Course Code	PCMEL609	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:2:0	ESE Marks	50
Credits	1	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET403 Engineering Thermodynamics	Course Type	Lab

Course Objectives:

1. To familiarize the various systems and subsystems of IC engines
2. To conduct the performance test on IC engines, compressors /blowers
3. To conduct the performance test on air conditioning and refrigeration systems

Expt. No.	Experiments
Study	a) Familiarisation of various systems and subsystems of petrol engine / MPFI engine b) Familiarisation of various systems and subsystems of Diesel engine / Turbocharged engine
1	Performance test on petrol engines / MPFI engine
2	Performance test on Diesel engines / Turbocharged engine
3	Heat Balance test on petrol/Diesel engines
4	Determination volumetric efficiency and Air-fuel ratio of IC engines
5	Cooling curve of IC engines
6	Valve timing diagram of IC engines
7	Economic speed test on IC engines
8	Retardation test on IC engines
9	Morse test on petrol engine
10	Analysis of automobile exhaust gas and flue gas using exhaust gas analyser
11	Performance test on reciprocating compressor

12	Performance test on rotary compressor/blower
13	Study and performance test on refrigeration (Refrigeration Test rig)
14	Study and performance test on air conditioning equipment (Air Conditioning test rig)
	Note : 8 Experiments are mandatory

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- *Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.*
- *Endorsement by External Examiner: The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify various systems and subsystems of Diesel and petrol engines	K1
CO2	Analyse the performance characteristics of internal combustion engines	K4
CO3	Investigate the emission characteristics of exhaust gases from IC Engines	K4
CO4	Interpret the performance characteristics of air compressors / blowers	K4
CO5	Interpret the performance characteristics of air conditioning and refrigeration systems	K4

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

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

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of IC engines,	V. Ganesan	Tata McGraw-Hill	4, 2017
2	I.C engine fundamentals,	J.B.Heywood	McGraw-Hill	2, 2018
3	An Introduction to Combustion: Concepts and Applications,	Stephen R Turns	McGraw-Hill	3,2011

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.

- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted