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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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	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	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. Interpolators: liner, circular and complete interpolator. Manual part programming - Computer aided part programming - APT. Programming exercises in turning, drilling and milling operations. *(At least one programming exercise must be included in the end-semester*	**11**

	examination).	
2	Programmable Logic Controllers (PLC) – input and output devices, ladder logic programming, simple problems only. 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).	**11**
3	Advanced Metal Forming Processes: High velocity forming of metals - Sheet metal forming - explosive forming - Electro hydraulic forming - Electro Magnetic Forming. Stress waves and deformation in solids – types of elastic body waves- relation at free boundaries- relative particle velocity. Microfabrication process: CVD, PVD, LIGA process. Micromachining: Diamond turn mechanism.	**11**
4	Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. - Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining. Material addition processes: - stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser-engineered net-shaping.	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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	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	**Conduction heat transfer** Modes of heat transfer – Mechanisms and laws of heat transfer – thermal conductivity, convective heat transfer coefficient, overall heat transfer coefficient 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. Transient heat conduction – Lumped system analysis – transient heat conduction analysis of bodies with non-negligible internal temperature	**8**

	gradient. Heat transfer through extended surfaces – classification of fins – heat 1transfer rate from a fin (rectangular fin, pin fin) – boundary conditions – fin effectiveness and fin efficiency. Introduction to finite difference method for steady state heat conduction analysis.	
2	**Convection heat transfer** 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. 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. Natural convection – natural convection heat transfer from vertical plate, horizontal and vertical cylinder. Heat exchanger – classification – design considerations and parameters – compact heat exchangers – effect of fouling- heat exchanger analysis – LMTD and NTU methods. Introduction to heat pipes.	**10**
3	**Radiation heat transfer** 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.	**10**
4	**Mass Transfer** Introduction to mass transfer – diffusion coefficient – Fick's law of	**8**

	diffusion- steady state diffusion in stationary medium- diffusion in moving medium- diffusion through a membrane. Convective mass transfer – non dimensional numbers – analogy between heat and mass transfer – correlations. 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)	

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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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** 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	6th edition, 2022
2	Heat and Mass Transfer elements	P.K Nag	Tata McGraw Hill	3th edition, 2011
3	Heat and Mass Transfer – Fundamental and Application	Yunus A. Cengel and Afshin J. Ghajar	McGraw Hill	6th edition, 2020
4	A text book on heat transfer	S.P. Sukhatme	Universities Press	4th 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	10th 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	1st 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	5th edition, 2011
3	Shigley's Mechanical Engineering Design	Richard G. Budynas, J. Keith Nisbett	McGraw Hill	11th edition, 2020
4	Design of Machine Elements	M. F. Spotts, T. E. Shoup	Pearson Education	8th 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	Project Management: Network construction, AON, AOA diagrams – Redundancy – CPM and PERT networks – Scheduling computations – PERT time estimates – Probability of completion of project – crashing Human resource management: Manpower planning, recruitment, selection, placement, training, development, performance management - Motivation - mechanism and theories	**9**
4	Operations management – Introduction - Concept of Productivity and its measurement – Forecasting – moving average – weighted moving average 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 Corporate Social Responsibility	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16marks)**	• 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 Weihrich 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

	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	
3	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.	**9**
4	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.	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 equation	**K2**
CO5	To apply the knowledge of CFD to interpret the graphicalresults	**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 numerical analysis	S SSastry	PHI learning Private Ltd	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 PBMET304	**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	Design for machining: Introduction to machining, Recommended materials for machinability, Machining Using Single-Point Cutting Tools, Machining Using Multipoint Tools. Design for tuning operation: Process description, typical characteristics and applications, Suitable materials, Design recommendations. Design for machining round holes: Introduction, Suitable materials, Design recommendations. Design for milling: Process description, Characteristics and applications of parts produced on milling machines, Design recommendations.	**9**
4	Sand casting: Introduction to sand casting, typical characteristics of sand cast part, Design recommendations. Die casting: Introduction, Applications, Suitable material consideration, Design recommendations. Injection moulding: Introduction, Typical characteristics of injection moulded parts, Effect of shrinkage, Suitable materials, Design recommendations. Welding process: Different types of welding processes, Design recommendations.	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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	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	2nd, 2009
3	Product Design and Development	Karl T. Ulrich, Steven D. Eppinger	McGraw Hill Education	7th 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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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	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 l D. W. Rosen l 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	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. 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. Energy statistics influence on energy consumption for oil rich countries. Global Influence of Oil-Rich Countries, Oil-Rich Countries Statistics, Geo-	9

	Political Influence, Energy Transitions, Energy Policy Shifts.	
2	Behaviour Change Approach to Promote and Sustain Energy Efficiency. Behaviour gaps, Biases, design thinking methodology, Ripple effect. 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. Energy efficiency and emission abatement relations. Abatement of emissions through energy efficiency, Sector wise analysis, Harnessing Renewable Energy Potential (Some country case studies).	**9**
3	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. 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. 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.	**9**
4	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. 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	

	acceptance. 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	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 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. **RECURITMENT & 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	**TRAINING:** Training- Need for training- Induction training-Effective training Programme process-Structural issues in Training. **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.	**9**
4	**LABOUR RELATIONS**: Relation between management and labours-Labour unions -objectives- Collective Bargaining -Negotiations-Strikes-Grievance Handling-Grievance redressal methods. **EMPLOYEE SAFETY AND HEALTH:** Employee safety- awareness – Accident prevention -creating safe environment -employee health problems and preventive measures-job stress – employee assistance programmes.	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 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	1ST 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	1st 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 2machines, 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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 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
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 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,