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	Introduction: Scope and functions of Industrial Engineering - Types of production (batch, flow and unit), Roles of line supervisors and production managers. 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. Plant layout and Material handling: Types of plant layout - Principles of material handling - Material handling equipment – Types, selection and application.	9
2	Production Planning and Control: Aggregate production planning, materials requirement planning - Inventory Management: EOQ models, discount models,	9

	P system, Q system, reorder level – Selective inventory control techniques - JIT - Supply chain and management. Break down, preventive and predictive maintenance.	
3	Lean Manufacturing (LM): Basic elements – Tools - Concept of wastes - stages of 5S and waste elimination - Need for LM. Agile manufacturing: Definition, business need, conceptual frame work, characteristics and generic features - Approaches to enhance agility in manufacturing - Managing people in agile organization. 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).	**9**
4	Quality Management: Quality, quality planning, quality control, quality assurance, quality management – TQM, ISO, Six Sigma and Quality circle (Brief description only). Statistical Quality Control - Process capability - Causes of variation in quality-Control charts for $\bar{x}$ and R – Acceptance sampling. Reliability Engineering - 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/ 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	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	Montegomery	Wiley Eastern	6th Edition, 2010
3	Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities	S. R. Devadasan, V. M. Sivakumar, R. Murugesh 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 wed 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, Lame'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
• 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	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	5th edition, 2018
2	Design of Machine elements	V.B.Bhandari	Tata McGraw Hill	5th 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	4th 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	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
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

	Steam turbines 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	
3	**Thermal power plants** General layout-site selection-fuel handling, storage and burning systems-dust and ash handling system-chimney draught **Nuclear power plants** Classification-components-safety measures-effects of nuclear radiation-nuclear waste disposal. **Gas turbine power plants** Classification-closed open and other systems **Hydro Electric Power Plants** Classification- Typical Layout and associated components	**9**
4	**Energy Storage** Pumped hydro, Compressed air energy storage, flywheel energy storage, Electrochemical energy storage, magnetic energy storage, Thermal energy storage, Chemical energy storage **Economics of power generation** 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. **Environmental pollution and its control** 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	**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	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, chocking, 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 chocking, 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
• 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 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	7th edition,2023
3	Gas Dynamics	E. Rathakrishnan	PHI Learning Pvt. Ltd.	7th 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	4th 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	**Principles of Lubrication:** Hydrodynamic lubrication, Boundary lubrication, Elasto-hydrodynamic lubrication (EHL) **Lubrication Regimes:** Thick film and thin film lubrication, Mixed lubrication, Stribeck curve and its significance **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	**9**
4	**Surface Treatments and Coatings:**Heat treatments, surface hardening, and nitriding, Coatings: PVD, CVD, thermal spray coatings, and electroplating **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 **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).	**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	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-IFToMM2008	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
• 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 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 Galekin 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, fibroscopes, 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

	MPI, system sensitivity, checking devices in MPI. **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.	
3	**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. **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.	**11**
4	**Advanced NDI Techniques:** Principle and Procedure of Digital Signal and image Processing & Digital Image correlation, Acoustic emission Inspection, Thermography, Computed Tomography	**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
• 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	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

	protection. 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.	
3	**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. Personal protection in the work environment, Types of PPEs, Respiratory and non-respiratory equipment. Standards related to PPEs. Hearing Conservation Program in Production industries.	**9**
4	**Safety issues in Machines**: Machinery safeguard, Principle of machine guarding -types of guards and devices. Safety in machining, welding and cutting. Material Handling-Classification-safety consideration- manual and mechanical handling-Maintenance of common elements-wire rope, chains slings, hooks, clamps. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate Housekeeping, Work permits system. Entry into confined spaces.	**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	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
• 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 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	1ST 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	Introduction to advanced materials, Advanced materials and alloys, Super alloy: Metallurgy and strengthening mechanisms, Types of super alloy and application. Bulk metallic glasses: Mechanism of formation, properties, and application. High Entropy Alloys (HEA): Thermodynamics, applications, Core effects of HEA, Phase selection in HEA. Self-healing materials: different self-healing processes. Materials for self-healing process.	**9**
2	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. Piezoelectric Materials: Direct and inverse Piezoelectric Effect, Materials used for piezoresistivity (Ceramics, Polymer and Composites), Single Crystal	**9**

	Piezoelectric. Smart Fluids: Electro-Rheological Fluids, Magneto -Rheological Fluid, Ferro Fluids, Photo-Rheological fluids, Materials used for ER, MR and PR fluids.	
3	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 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. Emerging photovoltaic materials	**9**
4	Ultralight materials: Aerogels, metallic and ceramic foams Biomaterials: Biocompatibility, Classification of biomaterials and applications. Surface modification of biomaterials-biocompatible coating, surface treatment, Advanced plastic materials, High temperature and conducting plastics, Biodegradable and Biorenewable Polymers/Plastics, Applications	**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	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	**Fundamentals of IC Engines**: Air standard cycles, their analysis, and applications - Otto cycle, Diesel cycle, Dual cycle, Atkinson cycle (No numerical problems and derivations) **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. **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.	**9**
4	**Combustion in IC Engines**: Fuels for IC engines, Ignition limits, air-fuel ratio, equivalence ratio. **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. **C.I. Engines**: Stages of combustion in C.I engines, Delay period, variables affecting delay period; knocking, Cetane rating of fuels. **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	**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
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 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

	Measures of Dispersion: Range - Inter QuartileRange -Standard Deviation - Variance and Coefficient of Variation. **Measures of Shape**- Skewness and Kurtosis.	
3	**Data Visualization**: Histogram- Bar Chart-Pie Chart-Scatter Plot-Coxcomb Chart-Box and Whisker Plot. **Correlation Analysis:** Pearson Correlation Coefficient-Spearman Rank Correlation. **Predictive Analytics**: Simple Linear Regression-Simple Linear Regression Model-Least Squares Method -Coefficient of Determination -Model Assumptions.	**9**
4	**Prescriptive Analytics**: Introduction **Business Performance Management:** Business Performance Management cycle-Performance management system-Key Performance Indicators. **Analytics in Business support functions**: Sales and Marketing - Human Resources-Financial Analytics-Production and Operations Analytics.	**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
• 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 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**
C07	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/xXDoZLVjfbs

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	Network analysis – Basic terms – Network construction, time analysis, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT). 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	**9**
4	Queuing theory: Scope, terminology, classification Importance and applications, Performance Measures in Queuing Systems, Single-server exponential arrival and service times. Multi - server problems. Simulation: Monte Carlo simulation – Queuing simulation model-Generation of random numbers	**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
• 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 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	**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. **Fuel, Air and ignition systems:** Carburettors(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.	**9**
3	**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.**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.	**9**
4	**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.**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.	**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
• 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 efficiency and performance of different automotive propulsion systems (electric, hybrid, internal combustion)	**K2**
CO2	Apply knowledge of automotive components to diagnose and troubleshoot issues in propulsion, transmission, and chassis systems.	**K3**
CO3	Describe the operation and integration of advanced automotive technologies such as fuel injection systems and electronic control units (ECUs) in vehicle design and performance enhancement.	**K2**
CO4	Understand basics of E & E architecture and principles behind vehicle handling and safety through analysis of steering, braking and suspension systems.	**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	Automobile Engineering, Vol.1 & Vol.2	Kirpal Singh	Standard Publishers	13th 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 &Hayley Pells	Routledge Publishers	3rd edition, 2022
6	Automobile Electrical and Electronic systems	Tom Denton	Routledge Publishers	5th 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	2nd 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 extend.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	The Energy Scenario- Commercial energy sources -World's production and reserves- India' Production and reserves. 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.	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
• 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	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- typesand 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
• 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	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	**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	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	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 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…)	
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
• 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 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

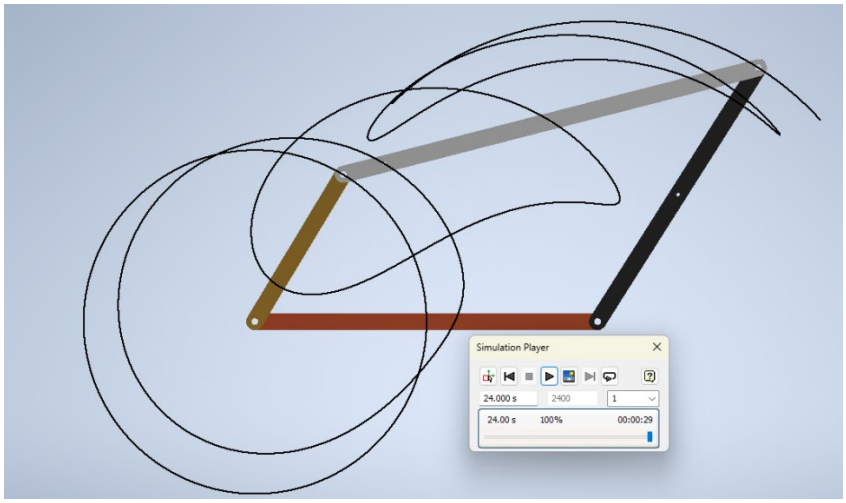
COMPUTER AIDED DESIGN AND ANALYSIS LAB

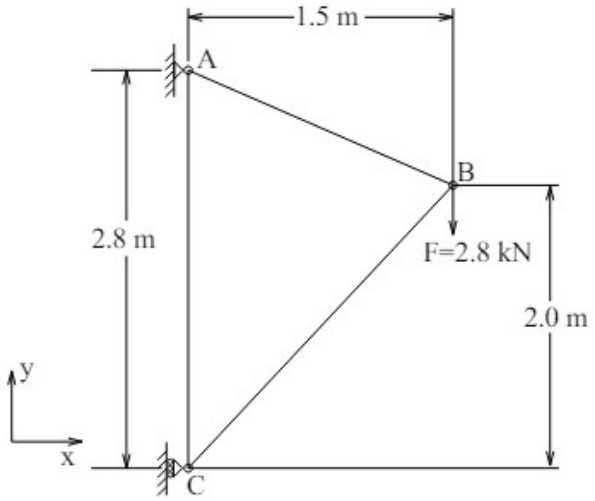
Course Code	**PCMEL607**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Computer Aided Machine Drawing (Course code - PCMEL307)	**Course Type**	Lab

Course Objectives:

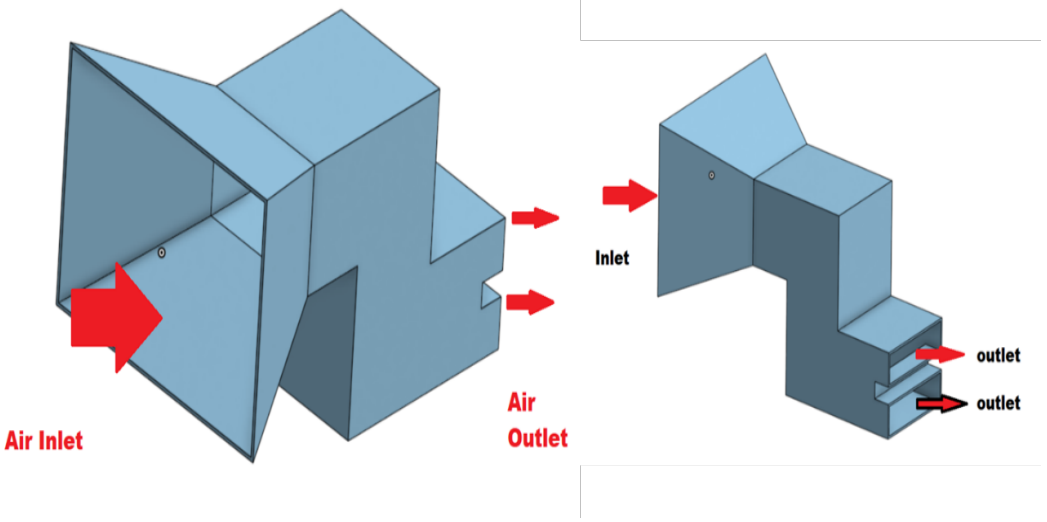
1. Teach students to design and simulate mechanical systems using CAD and FEA software. This includes creating mechanisms like the Whitworth quick return and four-bar linkage, and analyzing structural elements such as bars and trusses.
2. Enable students to perform dynamic simulations and analyze mechanical 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.

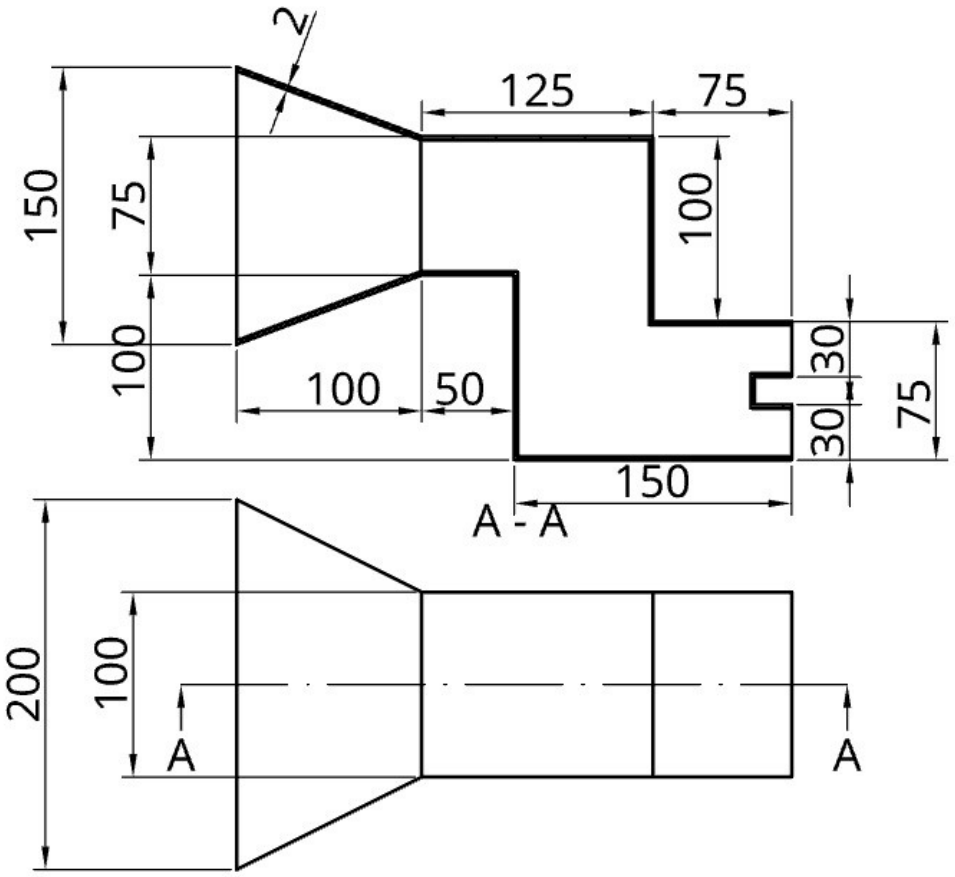
Expt. No.	Experiments
1	Perform a dynamic simulation of a four-bar mechanism. Example Problem Description. Perform a dynamic simulation of a four-bar mechanism using dynamic simulation. The dimensions of the mechanism are as follows: Crank = 100 mm, Coupler = 275 mm, Follower = 150 mm, and Fixed Link = 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

	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. 
2	Design and Simulation of a Whitworth Quick Return Mechanism 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 ofthe tool ram throughout the mechanism's cycle.
3	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. Example Problem Description: An axial bar of length L=1m is subjected to an axial tensile load P=10kN. The bar has three different cross-sectional areas along its length:Section 1: From x=0 to 0.3m, the cross-sectional area is A1 =50mm^2, Section 2: From x=0.3m to x=0.7m, the cross-sectional area is A2 =75mm^2, Section 3: From x=0.7m to x=1.0m, the cross-sectional area is A3 =100mm^2. The bar is fixed at the end with the smallest cross-sectional area (Section 1).
4	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

	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 $E = 2.1\times10^5$ 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	Perform an Eigen-buckling analysis using FEA software. Example Problem Description: 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.
9	Perform a fatigue analysis using FEA software. Example Problem Description: 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

	hub under these specified loading conditions.
10	Solve a steady-state heat conduction problem using FEA software to determine the temperature distribution within a solid material. Example Problem Description: 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, ρ = 7800 kg/m3, Specific heat capacity, C = 500 J/kgK. Boundary Conditions: Left edge (x= O mm): Maintained at a constant temperature T_1=100 C. Right edge (x= 200 mm): Maintained at a constant temperature T_2 =50 C. Top and bottom surfaces (y = O mm and y = 100 mm): Insulated (no heat flux). Front and back surfaces (z = O mm and z= 1O mm): Insulated (no heat flux).
11	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. Example Problem Description: 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 ρ= 2700 kg/m^3 , and a specific heat capacity of C= 900 J/kgK. Initially, the fin is at a uniform temperature of To = 25^0C. One end of the fin (x = 0 mm) is subjected to a constant heat flux of q = 2000 W /m^2, while the surrounding air temperature is T_{sur} = 25 ^{0} C with a convective heat transfer coefficient h = 10W/m^2 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 O 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.
12	Perform the 2D flow analysis of an airfoil

13	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 



- *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