SEMESTER 7

MECHANICAL ENGINEERING

SEMESTER S7

GAS TURBINE AND JET PROPULSION

Course Code	**PEMET741**	**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 Dynamics	**Course Type**	Theory

Course Objectives:

1. To be able to perform fluid dynamic and thermodynamic analysis of gas turbine engines

2. To understand the principles of various jet and rocket propulsion engines.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Gas Turbines – Introduction, fluid dynamics analysis of rotating machines, classification, energy equation, thermodynamic analysis, efficiency, basics of airfoil theory. Gas turbine cycles – open cycle, closed cycle, ideal cycle, simple cycle, heat exchange cycle and reheat cycle, intercooled cycle, intercooled with reheat and heat exchange. Cycle Analysis - Characteristics and properties of working medium, stagnation properties, compressor and turbine efficiencies, pressure losses, cycle efficiency.	**9**
2	Axial flow compressor – Working principle, velocity triangle, Work done, stage efficiency, degree of reaction, flow through blade rows, Losses, performance characteristics, comparison with centrifugal compressor Reaction turbines – single reaction stage, velocity triangle, work output, blade and stage efficiencies, multistage reaction turbines, blade to gas speed ratio, losses and efficiencies	**9**

3	Combustion – Theory of Combustion, factors affecting combustion chamber design and performance, process of combustion, combustion chamber geometry and arrangements, mixing and dilution. Inlet and nozzles – Subsonic inlets, diffuser, supersonic inlets, exhaust nozzles. Turbine blades: blade materials, manufacturing techniques, blade cooling, Applications of gas turbines, trends and future development, micro gas turbines – smart energy system.	**9**
4	Jet propulsion – Cycles and analysis – Gas turbine engines, Turboprop, Turbojet, Ramjet, Pulsejet, Thrust equation, Specific thrust of turbojet engine, efficiencies, factors affecting flight performance, Thrust augmentation Rocket propulsion – Classification, principle of rocket propulsion, optimum expansion ratio, solid propellant rocket and liquid propellant rocket, Nuclear propulsion, electro dynamic propulsion, photon propulsion, multistage rocket, propulsive efficiency.	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To **apply** the principles of thermodynamics and fluid dynamics to understand the performance and efficiency of various gas turbine cycles.	**K3**
CO2	To **analyze** the performance characteristics and efficiencies of axial flow compressors and reaction turbines	**K4**
CO3	To **analyse** the performance of gas turbine systems by understanding the characteristics of various components.	**K4**
CO4	To **understand** the principles and characteristics of jet and rocket propulsion 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	2	2	1	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	-	-	-	-	1
CO4	2	2	1	-	-	-	-	-	-	-	-	1

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Gas Turbines	V Ganesan	McGraw Hill Education	Third, 2017
2	Turbines, Compressors and Fans	S M Yahya	McGraw Hill	Fourth, 2011
3	Gas Turbine & Jet Rocket Propulsion	Mathur M L	Standard Publishers Distributors	First, 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Jet Engine	Rolls Royce	Wiley	First, 2015
2	Gas Turbine Theory	H. Cohen	Pearson Education	Seventh, 2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_ae19/preview
2	https://onlinecourses.nptel.ac.in/noc24_ae19/preview
3	https://onlinecourses.nptel.ac.in/noc24_ae19/preview
4	https://onlinecourses.nptel.ac.in/noc24_me96/preview

SEMESTER S7

AUTOMOBILE ENGINEERING

Course Code	**PEMET742**	**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 provide a comprehensive overview of the automotive industry and the historical evolution of automobiles, focusing on internal combustion engine (ICE) vehicles and their classifications.
2. To introduce and elaborate on the various systems and technologies used in modern automobiles, including fuel, ignition, lubrication, cooling, exhaust, power trains, suspension, brakes, and electronic systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction**: Overview of the automotive industry, History and evolution of automobiles, Combustion Engines (ICE) vehicles – classification of automobile L, M and N category (an overview). Sub division according to body style (hatchback to station wagon) **I C Engine components**: 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.	9
2	**Fuel, Air and ignition systems:** Carburettors, MPFI, CRDI & GDI systems with components (with neat diagrams). 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. **Lubrication, Cooling and exhaust system:** Lubrication system – basic	9

	circuitry, oil grade and viscosity. Cooling system – basic circuit including thermostat valve. Exhaust system – 3-way catalytic converter, DPF and SCR basics.	
3	**Power Trains:** General arrangement of clutch, Principle of friction clutches, Constructional details, Single plate and multi-plate. Numerical calculations for torque transmission by clutches. Gear box: Necessity for gear ratios in transmission, synchromesh gear boxes, planetary gears, over drives, principle of automatic transmission (AMT, CVT, DCT, TC – an overview). **Drive to Wheels:** Propeller shaft and universal joints, differential, rear axle, Ackerman Steering Mechanism, steering geometry, camber, king pin inclination, included angle, castor, toe in & toe out, steering gears, power steering, general arrangements of links and stub axle, types of chassis frames.	**9**
4	**Suspension, Springs and Brakes**: Requirements, leaf spring, coil spring, independent suspension for front wheel and rear wheel. Air suspension system. Types of brakes, mechanical, hydraulic and air braking systems, brake shoe arrangements, Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system. **Electronics:** 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: 40marks, 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 and classify various types of automobiles and their evolution.	**K2**
CO2	Identify and explain the components and functioning of Internal Combustion Engines (ICE)	**K3**
CO3	Describe and analyse the various fuel, air, ignition, lubrication, cooling, and exhaust systems in vehicle.	**K4**
CO4	Explain the power train, drive to wheels, suspension, springs, and braking systems.	**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	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	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	Automotive Electrics and Automotive Electronics	Robert Bosch GmbH	John Wiley & Sons	5th (2014)
7	Automotive Control Systems: For Engine, Driveline, and Vehicle	Uwe Kiencke and Lars Nielsen	Springer	2nd (2005)

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Automotive Technology: Principles, Diagnosis, and Service	James D. Halderman	Pearson	5th (2019)
2	Automotive Engineering: Powertrain, Chassis System and Vehicle Body	David Crolla	Butterworth-Heinemann	1st (2009)
3	The Internal Combustion Engine in Theory and Practice	Charles Fayette Taylor	MIT Press	2nd (1985)
4	Costs and Productivity in Automobile Production	Melvyn A. Fuss, Leonard Waverman,	Cambridge University Press	1, 2006
5	Automotive Lubricants Reference Book	Arthur J. Caines	SAE International	2nd (2004)
6	Automotive Transmissions and Transaxles	Thomas W. Birch	Pearson	5th (2018)
7	Automotive Suspension and Steering Systems	Thomas W. Birch	Pearson	5th (2018)
8	Understanding Automotive Electronics	William B. Ribbens	Butterworth-Heinemann	8th (2017)

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/107/106/107106088/ https://archive.nptel.ac.in/courses/112/103/112103262/
2	https://archive.nptel.ac.in/courses/107/106/107106088/ https://archive.nptel.ac.in/courses/112/102/112102014/
3	https://archive.nptel.ac.in/courses/107/106/107106088/ https://onlinecourses.nptel.ac.in/noc22_me96/preview
4	https://nptel.ac.in/courses/107106080 https://nptel.ac.in/courses/108102045

SEMESTER S7

DESIGN OF MACHINE ELEMENTS

Course Code	**PEMET743**	**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)	PBMET604 Machine Design	**Course Type**	Theory

Course Objectives:

1. To develop a comprehensive understanding of the fundamental principles and theories involved in design.
2. To familiarize students with international standards and codes.
3. To teach the systematic approach to design.
4. To enable students to select appropriate materials based on mechanical properties.
5. To analyze and predict potential failure modes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Design of Shafts:** Design of Shafts Based on Bending Moment, Twisting Moment, Combined Bending & Twisting Moments, Axial Loads in Addition to Combined Torsional and Bending Loads, Rigidity and Stiffness.	7
2	**Design of IC Engine parts:** General design considerations, Design of cylinder and cylinder head, Design of piston and its parts, Design of connecting rod, Design of crankshaft. **Design of Clutches:** Design considerations, Friction clutches, Multiple disc clutches, Cone clutch, Centrifugal clutch. **Design of Brakes:** Block brake, band brake, band and block brake, internal expanding shoe brake.	9
3	**Bearings and Lubrication:** Introduction to lubrication, types of lubrication and lubricants viscosity, Design of journal bearings, Sommerfield Number, bearing materials, heat balance, bearing housing and mountings. **Rolling contact bearings:** Bearing types, Ball& roller bearings, Static and	8

	Dynamic load capacity, Equivalent dynamic load, Bearing life, Stribeck's equations, selection of bearings.	
4	**Design of gears:** Nomenclature: spur, helical, bevel and worm gears, gear materials, tooth loads, design stresses, basic tooth stresses, stress concentration, service factor, velocity factor, bending strength of gear tooth, Lewis equation and Lewis form factor. Working stress in gear teeth, Dynamic load and wear load on gear teeth, Buckingham's equation for dynamic load, surface strength and durability, design for strength and wear, Design of spur gear, Helical gear, bevel gear and worm gear.	**12**

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	Model suitable transmission system for the stated conditions	**K3**
CO2	Make use of the design procedure for I C engine components	**K3**
CO3	Develop of Sliding contact bearing for industrial applications.	**K3**
CO4	Choose a suitable Rolling contact bearing from manufacturer's Catalogue for a specific application	**K3**
CO5	Model suitable spuror helical gear drive based on the industrial requirements.	**K3**
CO6	Apply the design procedure for bevel and worm gear drives for specific application.	**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	3	3	3	-	-	2	-	-	-	-	-	1
CO2	3	3	3	-	-	2	-	-	-	-	-	1
CO3	3	3	3	-	-	2	-	-	-	-	-	1
CO4	3	3	3	-	-	2	-	-	-	-	-	1
CO5	3	3	3	-	-	2	-	-	-	-	-	1
CO6	3	3	3	-	-	2	-	-	-	-	-	1

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design of Machine Elements	V B Bhandari	McGraw Hill Education (India)	5th Edition, 2020
2	Machine Design – An Integrated Approach	R. L. Norton	Pearson Education	5th Edition, 2018
3	Design of Machine Elements II	Raghavendra K	CBS Publishers and Distributors Pvt Ltd	1st Edition 2019
4	Machine Design	Dr P.C. Sharma Dr D.K. Agarwal	S.K. Kataria& Sons	2017
5	Machine Design Data Book	V B Bhandari	McGraw Hill Education (India) Private Limited	2nd edition 2019
6	Design Data Hand Book	K. Mahadevan, K. Balaveera Reddy	CBS Publishers & Distributors	4th Edition, 2019
7	PSG Design Data	PSG Tech	DPV Printers, Coimbatore	2022

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 Design, Volume 1, 2	Ajeet Singh	Cambridge University Press	1, 2022
3	Fundamentals of Machine Component Design	Juvinall R.C, Marshek K.M.	John Wiley	5th Edition 2011
4	Design of Machine Elements	M. F. Spotts, T. E. Shoup	Pearson Education	8th Edition 2019
5	Machine Elements: 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/112/105/112105234/

SEMESTER S7

FAILURE ANALYSIS AND DESIGN

Course Code	PEMET744	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	Course Type	Theory

Course Objectives:

1. **Understand** the fundamental theories and modes of failure to prevent catastrophic failures in engineering materials.
2. **Apply** principles of fatigue loading, life prediction, and fracture mechanics to design against material failure under various conditions.
3. **Analyse** advanced failure mechanisms such as contact fatigue, high-temperature effects, and corrosion, integrating fracture mechanics principles for complex loading conditions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Failure Modes and Theories of Failure** Identification of failure modes, Combined stresses, Theories of failure, Maximum Stress Theory, Maximum Strain Theory, von Mises Stress Theory, Material behaviour under different loading conditions, Failure mechanisms, Preventing catastrophic failures	9
2	**Fatigue Loading and Life Prediction** Fatigue loading, High cycle fatigue, Fatigue testing, S-N-P curves, Factors affecting S-N-P curves, Endurance diagrams, Cumulative damage, Life prediction, Fracture control, Fatigue design for combined stress.	9
3	**Low Cycle Fatigue and Fracture Mechanics** Low cycle fatigue, Cumulative damage in low cycle fatigue, Stress concentration factors, Notch sensitivity, Principles of fracture mechanics, Crack initiation, Crack propagation, Designing against fatigue and fracture,	9

	Application of fracture mechanics in design practice.	
4	**Advanced Topics in Failure Analysis** Contact fatigue, High-temperature effects, Corrosion, Shock and impact loading, designing for contact fatigue, Influence of high temperatures on material properties, Mechanisms of corrosion and prevention, Integration of fracture mechanics principles, Designing for complex loading conditions.	**9**

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 different theories of failure and material behaviour under various loading conditions.	**K2**
CO2	Remember the factors affecting fatigue loading, S-N-P curves, and endurance diagrams for life prediction**.**	**K1**
CO3	Apply principles of fracture mechanics to analyse and design against crack initiation and propagation.	**K3**
CO4	Understand advanced failure mechanisms, including contact fatigue, high-temperature effects, and corrosion, and their impact on material properties and design.	**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	3	2	-	2	2	2	-	-	-	-	3
CO2	3	3	2	1	-	2	2	-	-	-	-	2
CO3	3	3	3	2	3	3	3	1	2	2	2	3
CO4	3	3	2	2	2	3	3	1	1	1	2	3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Materials 3– Materials Failure Analysis: Case Studiesand Design Implications	Jones D. R. H	Pergamon Press	1993.
2	"Failure Analysis and Prevention"	ASM Handbook, Vol. 11	Edited by, ASM Publications	2002
3	Failure of Materials in Mechanical Design	Jack A.Collins	Wiley Inter science Publishers	2013.,2nd Edition
4	Elements of Fracture Mechanics	Prashant Kumar	Wheeler Publishing,	1999.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107241/
2	https://archive.nptel.ac.in/content/storage2/courses/105108072/mod01/hyperlink-4.pdf
3	https://archive.nptel.ac.in/content/storage2/courses/112108150/pdf/PPTs/MTS_08_m.pdf
4	https://archive.nptel.ac.in/content/storage2/courses/113108051/module1/lecture1.pdf https://www.digimat.in/nptel/courses/video/113104082/L01.html

SEMESTER S7

LEAN MANUFACTURING

Course Code	**PEMET746**	**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. Students will able to learn about lean manufacturing, types of industrial wastes associated and tools for eliminating the wastes.
2. Students will understand about the lean elements and identify those within industries.
3. Students can understand the concept of six sigma and agile manufacturing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction - History of Lean – Toyota Production System (TPS)- Ford Production System (FPS)- Principle of Lean Manufacturing- Seven Wastes, their causes and the effects- Conventional Manufacturing versus Lean Manufacturing	**8**
2	Tools of Lean manufacturing: 5-S, Workplace organization, Total Productive Maintenance, Process mapping/ Value stream mapping, Work cell, Cause and Effect diagram, Pareto chart, Spider chart, Poka yoke, Kanban, Automation, Single minute exchange of die (SMED), Just in time (JIT), Visual workplace, OEE	**10**
3	Lean elements: Introduction to Lean Concepts like In-Built Quality, Concept of Right Part at the Right Time, Lead Time reduction, Optimum utilization of Capital, Optimum utilization of People. Understanding the Zero-defect concept and Metrics, Focus on Human Resources, Quality and Delivery Cost. Building Zero defect capabilities, Cultural and Organizational aspects	**8**

4	Six Sigma Fundamentals: Introduction to six sigma- basic tools of six sigma like problem solving approach, standard deviation, normal distribution. DMAIV and DMADV. Agile Manufacturing: Agile manufacturing - Definition, business need, conceptual frame work, characteristics, and generic features -Approaches to enhance ability in manufacturing - Managing people in agile organization	**10**

Course Assessment Method
(CIE: 40marks, 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	Identify and understand the key concepts in lean manufacturing.	**K1, K2**
CO2	Select the lean manufacturing tools to find and eliminate wastes	**K3**
CO3	Identify and improve a manufacturing system by applying lean manufacturing principles and tools	**K3**
CO4	Understanding the key concepts of six sigma	**K2**
CO5	Identify the framework of agile manufacturing	**K1, 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	1	-	-	-	-	3	3	3	3	3	2	3
CO2	1	-	-	-	-	2	3	2	3	3	2	3
CO3	1	-	-	-	-	3	3	2	3	3	2	3
CO4	1	-	-	-	-	3	3	2	3	3	2	3
CO5	1	-	-	-	-	3	3	2	3	3	2	3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Machine that Changed the World: The Story of Lean Production	James P. Womack, Daniel T. Jones, and Daniel Roos	Simon & Schuster	1996
2	Becoming Lean	Jeffrey K. Liker	Industrial Engineering and Management Press	1997
3	Demystifying six sigma: a company-wide approach to continuous improvement	Larson, Alan	Jaico, Mumbai	2007
4	Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities	S.R. Devadasan, V. Mohan Sivakumar, R. Murugesh and PR Shalij	PHI Learning private Limited, New Delhi	2012
5	The Cambridge International Handbook of Lean Production	Thomas Janoski, Darina	Cambridge University Press	1, 2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Lean Thinking	James P. Womack and Daniel T. Jones	Free Press-Business and Economics	2003
2	Learning to See	Rother M. and Shook J	The Lean Enterprise Institute, Brookline	2003
3	Lean six sigma: combining six sigma quality with lean speed	George, Michael. L.	Tata McGraw Hill Education, New Delhi	2002
4	Lean Evolution	Nick Rich, Nicola Bateman,	Cambridge University Press	1, 2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/104/112104188/
2	https://archive.nptel.ac.in/courses/112/104/112104188/
3	https://archive.nptel.ac.in/courses/112/104/112104188/
4	https://archive.nptel.ac.in/courses/112/104/112104188/

SEMESTER S7

RELIABILITY ENGINEERING

Course Code	PEMET747	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 induce an attitude towards reliability engineering in students which will ensure that they can identify steps to avoid failures in their future assignments.
2. To understand the basic principles of reliability engineering and its applications to various systems in engineering

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Reliability Concepts: Definition of reliability, Reliability vs. Quality, Reliability function, MTTF and MTBF, Hazard rate function, Bathtub curve, Derivation of the reliability function, Failure and Failure modes, Causes of Failures and Unreliability. Hazard Models: Constant hazard model, Linearly increasing hazard models, Weibull model. System Reliability: Series and parallel configurations, Combined series parallel systems, k-out-of-m systems, standby systems.	9
2	Redundancy Techniques in System design: Component and Unit redundancy, Weakest-link Technique, Mixed redundancy, Redundancy optimization. State - Dependant Systems: Markov analysis, Single and two independent components, Load sharing systems, Standby system, Degraded systems. Reliability Allocation: Equal, ARINC, and Proportional apportionments,	9

	AGREE method.	
3	System Analysis and Reliability Estimation: Fault tree analysis, Event tree analysis, FMEA and FMECA, Tie - set and Cut - set methods. Design for reliability: Load -Strength Interference and safety Margin Software reliability: Software errors; Fault Tolerance; Data Reliability; Hardware and Software Interfaces. Reliability prediction Standards: MIL 217 and NSWC Standards. Human reliability: Methods for Human Reliability Analysis. Economics of Reliability: Optimizing Reliability Cost`	**9**
4	Availability: Definitions and Basic Concepts; Inherent availability; Achieved availability; Operational availability; Availability of Series and Parallel Systems. Maintenance: Preventive, predictive and reliability cantered maintenances, Maintainability - Instantaneous Repair Rate and Maintainability Function, MTTR. Life Testing: Objectives and Types, Censoring; Accelerated Life Testing, HALT, HASS.	**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 various modes of failure and basic concepts of reliability	**K2**
CO2	Identify methods for reliability prediction according to system characteristics	**K3**
CO3	Develop ability in formulating suitable strategies to enhance reliability of a manufacturing system.	**K3**
CO4	Explain relation between reliability, availability and maintainability	**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	2	3	2	-	-	-	-	-	-	-	-	-
CO3	2	2	3	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Reliability Engineering	Balagurusamy	McGraw Hill Education	17th Reprint, 2017
2	Quality and Reliability in Engineering	Tirupathi R. Chandrupatla,	Cambridge University Press	1, 2009
3	Concepts of Reliability Engineering	L.S. Srinath,	Affiliated East-West Press	4th Edition, 2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An introduction to Reliability and Maintainability Engineering	Ebling C. E.	Tata McGraw Hill	12th Edition, 2004.
2	Reliability Engineering and Life Testing	Naikan V. N. A.	PHI	1st Edition, 2008
3	Introduction to Reliability Engineering	Lewis E. E.	Wiley India	2nd Edition, 2012
4	Engineering Reliability	Richard E. Barlow	Cambridge University Press	1, 1998

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/127/105/127105234/
2	https://archive.nptel.ac.in/courses/127/105/127105234/
3	https://archive.nptel.ac.in/courses/127/105/127105234/
4	https://archive.nptel.ac.in/courses/127/105/127105234/

SEMESTER S7

ROBOTICS

Course Code	**PEMET748**	**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. This course helps the student to the basic idea of Robots. Students are introduced to the basic design considerations of robots.
2. Concepts like trajectory planning and obstacle avoidance and kinematics of robots are introduced.
3. Discussion on various mobile robots and robotic manipulators are also included as part of the course to get an overall idea on robotics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots. Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in the robot.	9
2	Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous coordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (up to 3DOF). Inverse kinematics-general properties of solutions and problems (up to 3DOF).	10

	Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only). Tool configuration Jacobian, relation between joint and end effector velocities.	
3	Manipulator Dynamics: Lagrange's formulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots up to 2 DOF, modelling including motor and gearbox.	**8**
4	Trajectory Planning. Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, point-to-point vs. continuous path planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms. Robot Control: The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control	**9**

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	Familiarise with anatomy, specifications and types of Robots	**K2**
CO2	Obtain forward and inverse kinematic models of robotic manipulators	**K2**
CO3	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion	**K2**
CO4	Develop a dynamic model and design the controller for robotic manipulators	**K2**
CO5	Choose the appropriate Robotic configuration and list the technical specifications for robots used in different application	**K2**

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

CO-PO Mapping Table:

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Robotics – Analysis and Control	Robert. J. Schilling	Prentice Hall of India	1996
2	Introduction to Robotics (Mechanics and Control)	John. J. Craig	Pearson Education Asia	2002
3	Introduction to Robotics	S K Saha,	McGraw Hill Education	
4	Robotics and Control	R K Mittal	Tata McGraw Hill, New Delhi	2003
5	Robotics-Fundamental concepts and analysis	AshitavaGhosal	Oxford University Press	
6	Modern Robotics Mechanics Planning and Control	Kevin M.Lynch, Frank.C.Park	Cambridge University Press	1, 2017
7	Statics and Kinematics with Application to Robotics	Joseph Duffy	Cambridge University Press	1, 2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Robotics	Siciliano, Khatib	Springer	
2	, Introduction to Robotics – Mechanics and Control	John J. Craig		
3	Modern Robotics Mechanics, Planning and Control	. Kevin M. Lynch, Frank C. Park,		
4	Robotics Modelling, Planning and Control	Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo	Springer	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/105/112105249/
2	https://archive.nptel.ac.in/courses/112/105/112105249/
3	https://archive.nptel.ac.in/courses/112/105/112105249/
4	https://archive.nptel.ac.in/courses/112/105/112105249/

SEMESTER S7

MECHATRONICS

Course Code	PEMET745	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	Course Type	Theory

Course Objectives:

1. To introduce the students to the concepts of mechatronics
2. To understand behaviour of sensors and actuators.
3. To understand different controllers for mechatronic systems and program them.
4. To review typical case studies involving mechatronics and appreciate the mechatronic system design process.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Sensors and signal conditioning**: Introduction to Mechatronics: Structure of Mechatronics system. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute, gray coded encoder. Piezoelectric sensors. Acoustic Emission sensors. Principle and types of vibration sensors. Signalconditioning, need and methods. Op amp configurations. Current/Resistance/reactance to voltage circuits, bridge circuits applications. ADC and DAC circuits. Basics of sampling theorem.	9
2	**Actuators:** Mechanical actuators, Electrical actuators, Hydraulic and Pneumatic actuators. Basic mechanical elements: guide ways, drives. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing. Re-circulating ball screws, pre-loading methods. Re-circulating roller screws. Pneumatics and hydraulics. Directional control valves, pressure control valves, process control valves. Rotary actuators.	9

	Development of simple hydraulic and pneumatic circuits using standard Symbols. Electric motors, ac, dc, bldc and stepper motors, torque-speed characteristics	
3	**Control of mechanical systems**: System modeling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Microcontrollers and architecture. Use of microcontrollers for mechatronic applications Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of ladder programs for specific purposes.	**9**
4	**Modern mechatronic systems:** Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope. MEMs devices for biomedical applications. Mechatronics in automobiles. Sensors ECU, ABS, Cruise control. Mechatronics in robotics, sensors and drives for robots.	**9**

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 characteristics and working of sensors and choose the optimal one based on the application	**K2**
CO2	Understand the characteristics and working of actuators and choose the optimal one based on the application	**K2**
CO3	Understand the basics of mathematical modelling of the given real systems and to predicts its behaviour	**K2**
CO4	Understand the use of PLC for industrial and product automation and to create ladder programs for applications	**K3**
CO5	Understand the use and characteristics of microcontrollers and choose the appropriate one based on the given application	**K3**
CO6	Understand the characteristics of MEMs devices and incorporate them in mechatronic applications	**K2**
CO7	Understand the use of mechatronic concepts in modern applications.	**K2**

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

CO-PO Mapping Table:

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	W. Bolton	Pearson	7th
2	Mechatronics: Principles and Applications	Godfrey C. Onwubolu	Elsevier	
3	Mechatronics System Design	DevdasShetty, Richard Kolk	PWS Pub	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	A Text Book of Mechatronics	R.K. Rajput	S. Chanth	First edition 2007

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107298/
2	https://archive.nptel.ac.in/courses/112/107/112107298/
3	https://archive.nptel.ac.in/courses/112/107/112107298/
4	https://archive.nptel.ac.in/courses/112/107/112107298/

SEMESTER S7

REFRIGERATION AND AIRCONDITIONING

Course Code	**PEMET751**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET403 Engineering Thermodynamics	**Course Type**	Theory

Course Objectives:

1. To master fundamental principles and applications of Refrigeration and Air Conditioning
2. To develop proficiency in thermodynamic analysis and understanding of components:

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to refrigeration and air conditioning, ideal refrigeration cycles, Aircraft refrigeration cycles.** Definition of refrigeration and air conditioning, Relationship of refrigeration and air-conditioning fields, Applications of refrigeration and air-conditioning, unit of refrigeration. Ideal refrigeration cycle- Reversed Carnot cycle, refrigerator and heat pump, coefficient of performance (COP) , Gas and Vapour as refrigerant in reversed Carnot cycle, Revisions of the reversed Carnot cycle- reversed Brayton cycle and simple vapour compression refrigeration cycle. Simple aircraft refrigeration system with ram compression, Boot strap refrigeration system, Regenerative and Reduced ambient systems	9

2	**Thermodynamic analysis of vapour compression and vapour absorption refrigeration systems.** Simple vapour compression refrigeration system, representation of the cycle on T-s and P-h diagram, Use of refrigerant tables and charts, Effect of operating on COP suction line heat exchanger, actual vapour compression refrigeration system. Limitation of single stage refrigeration systems in achieving ultra-low temperature. Cascade refrigeration system and Trans-critical refrigeration system (Numerical Problems to be limited to Refrigerants R134a, R32, R1234yf, R410A, R744, R718, R744) Principle of vapour absorption system, desirable properties of refrigerant and absorbent pairs, Working of continuous vapour absorption system, ideal COP of absorption system, LiBr-Water absorption system, NH_3-Water absorption system, Use of charts to calculate the performance of vapour absorption refrigeration system (Numerical problem limited to LiBr-Water absorption system), Comparison of vapour absorption and vapour compression system. Three fluid absorption system.	**9**
3	**Refrigerants and refrigeration system components** Types of refrigerants, designation of refrigerants, Ozone depletion and Global warming, commonly used refrigerants- HFC, HC,HFO and mixed refrigerants, desirable physical, chemical and thermodynamic properties of refrigerants. Types of expansion devices – Constant pressure valve-Thermostatic expansion valve and capillary tube, Electronic Expansion valves. Types of compressors in refrigeration systems, Types of evaporators and condensers, Cooling towers.	**9**
4	**Psychrometry and applied psychrometry** Properties of moist air- specific humidity. Dew point temperature, Relative humidity, Enthalpy of moist air, wet bulb and thermodynamic wet bulb temperatures, Psychrometric chart, Typical air conditioning processes, Air washer, sensible heat factor, grand sensible heat factor, effective sensible heat factor, Simple air conditioning system, Summer air-conditioning system, Winter air-conditioning system, year round air-conditioning systems – Representation on the Psychrometric chart and estimation of quantities.	**9**

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	Define and describe the basic concepts and applications of refrigeration and air conditioning and analyse performance of ideal refrigeration cycles	**K2, K4**
CO2	Explain the principles and evaluate the efficiency of aircraft refrigeration systems,	**K2, K5**
CO3	Perform Thermodynamic Analysis of Vapour Compression and Absorption Systems.	**K3, K4**
CO4	Explain and Select Appropriate Refrigerants and System Components	**K2. K3**
CO5	Analyse properties of moist air using psychrometric principles and chart and explain the working principles and applications of air washers and air-conditioning systems.	**K2, 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	3	-	-	-	-	-	-	-	-	2
CO2	3	3	3	-	-	-	-	-	-	-	-	2
CO3	3	3	3	-	-	-	-	-	-	-	-	2
CO4	3	2	1	-	-	-	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	Refrigeration and Air Conditioning	Arora C.P	Tata McGraw hill	4th edition/2021
2	Refrigeration and Air Conditioning	Ramesh Cahndra Arora	PHI	4th Printing/2015
3	A Course in Refrigeration and Air Conditioning	Arora S. C. and S. Domkundwar	Dhanpat Rai and Company.	2018
4	Refrigeration and air conditioning -	Ahamadul Ameen.	Eastern economy addition	2020
5	Air Conditioning Engineering	W P Jones	Spon Press	5th edition/ 2001
6	Data book- Refrigeration tables and charts including air conditioning data	C P Kothandaraman	New Age International.	2023

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	ASHRAE Handbook	The American Society of Heating, Refrigerating and Air-Conditioning Engineers		
2	Basic Refrigeration and Air Conditioning	P NAnanthanarayanan	McGraw Hill	4th Edition 2013
3	Refrigeration & Air-conditioning	Stoecker & Jons	McGraw Hill	2nd edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Refrigeration and Air-conditioning By Prof. Ravi Kumar | IIT Roorkee
2	Refrigeration and Air-conditioning By Prof. Ravi Kumar | IIT Roorkee
3	Refrigeration and Air-conditioning By Prof. Ravi Kumar | IIT Roorkee
4	Refrigeration and Air-conditioning By Prof. Ravi Kumar | IIT Roorkee

SEMESTER S7

ACOUSTICS AND NOISE CONTROL

Course Code	**PEMET752**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To understand the acoustics principle
2. To give awareness about different acoustic measurement devices
3. To bring importance to noise control

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Acoustics, sound and noise, generation of sound, Acoustic pressure, Puretone and rms values, speed of sound, frequency, wavelength, period, relation between them; Particle velocity; Acoustic impedance; Acoustic power and intensity, Inverse square law; Acoustic energy density; Spectrum, frequency bands and octave. Development of Acoustic wave equation, plane wave equation and D-Alembert's solution, Helmholtz equation(frequency-domain); plane waves and spherical waves Levels, decibel, sound pressure level, sound power level, and sound intensity level. Addition, subtraction, and averaging of decibel.	**10**
2	Point source, spherical source, Line source, Monopole, dipole; Lateral and longitudinal quadrupole; Array of N sources and continuous line array of sources; baffled piston, Near-and far-field spectrum; Directivity: Directivity pattern; Beam width; Directivity factor and directivity index. Sound transmission: Transmission through two media-Normal and oblique incidence; Transmission and reflection coefficients (pressure, intensity and power), transmission loss; Absorption coefficient Sound propagation in open or a closed tube; Standing waves	**10**
3	Ear its structure and function; Subjective and objective assessment of	**10**

	sound; Hearing threshold ; Octave band analysis ; Sound level frequency weightings; Equivalent sound level ; Loudness; Equal loudness contours ; Phones and sones ; Hearing loss; Masking Speech interference level; Perceived noise level; Noise and number index; Need for noise criteria, regulations and standards; NC, PNC, and NCB curves; Noise dose; Industrial noise criteria (OSHA standards). Microphones-principle and types; Sound level meters; Sound intensity probes; Dosimeters; Sound measurement in anechoic and reverberation chambers; Measurement of directivity factor.	
4	Noise control at source; Control during transmission; Control at Receiver, Causes of noise and noise control in pumps, compressors, fans, Electric motor, Cooling towers. Acousticen closures; Barriers; and absorbers-porous, fibrous, foams, resonance; Acoustic filters; Helmholtz resonator, Plenum chamber. Mufflers- active and passive-reactive and dissipative; Transmission loss and design procedure for Expansion Chamber Mufflers.	**6**

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 define various acoustic terminologies and understand the physics behind acoustic wave propagation	**K2**
CO2	To analyse the transmission of sound through different media and tubes	**K4**
CO3	To understand the mechanism of hearing, noise regulations and noise measuring devices	**K2**
CO4	To explain various noise reducing measures	**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					3				3		3
CO2	3	3		3		3				3		3
CO3	3		3			3	3			3		3
CO4	3	3	3	3		3	3			3		3

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Noise and vibration control engineering	Istvan L. Ver and Leo L. Beranek	Wiley	Second edition, 2006
2	Fundamentals of Acoustics	Lawrence E Kinsler, Austin R Frey, Alan B Coppens, James V Sanders	Wiley	Fourth edition, 2000

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Noise and Vibration Control	M L Munjal	World Scientific publishing	2013
2	Handbook of Noise and Vibration Control	Malcom J Crocker	Wiley	2007
3	Industrial Noise Control and Acoustics	Randall F. Barron	Marcel Dekker, Inc., New York.	2001
4	Mechanical Vibrations and Industrial Noise Control	Lasithan L G	PHI Learning	2014

SEMESTER S7

AEROSPACE ENGINEERING

Course Code	**PEMET753**	**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. Understanding Atmospheric and Aerodynamic Fundamentals
2. Analysing 3D Aerofoils and Wing Performance
3. Evaluating Aircraft Performance and Flight Dynamics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	The atmosphere - characteristics of troposphere, stratosphere, thermosphere, and ionosphere - pressure, temperature and density variations in the atmosphere.	9
2	2D aero foils -Nomenclature and classification- pressure distribution in inviscid and real flows- momentum and circulation theory of aero foil- characteristics	9
3	3D or finite aero foils — effect of releasing the wingtips- wing tip vortices- replacement of finite wing by horseshoe vortex system, lifting line theory- wing load distribution — aspect ratio, induced drag calculation of induced drag from momentum considerations. Skin friction and from drag- changes in finite wing plan shape	9
4	Propellers — momentum and blade element theories —propeller coefficients and charts. Aircraft performance-straight and level flight —power required and power available graphs for propeller and jet aircraft. Gliding and climbing —rate of climb-service and absolute ceilings-gliding angle and speed of flattest glide, take-off and landing performance — length of runway required- aircraft ground run- circling flight — radius of tightest turn-jet and rocket assisted take —off, high lift devices-range and endurance of airplanes-charts for piston and jet engine aircrafts	9

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	Describe the characteristics of the atmosphere and understand the Theory of 2D Aerofoils.	K2
CO2	Evaluate the effects of wingtip vortices on 3D Aerofoils, calculate induced drag using lifting line theory, and understand the impact of finite wing plan shapes on aerodynamic performance.	K2
CO3	Assess aircraft performance metrics such as power requirements, rate of climb, service ceilings, and gliding angles, and apply this knowledge to both propeller and jet aircraft.	K3
CO4	Explain the principles and functions of essential flight instruments, including airspeed indicators, altimeters, and gyroscopic instruments, and perform basic calculations such as true airspeed.	K2
CO5	Gain a qualitative understanding of aircraft stability and control, including static and dynamic stability, and the aerodynamic and mass balancing of control surfaces.	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	-	-	-	-	-	-	-	-	1
CO2	3	2	1	1	-	-	-	-	-	-	-	-
CO3	3	2	-	-	1	-	-	-	-	-	-	-
CO4	3	-	-	-	1	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mechanics Of Flight	A. C. Kermode, Revised By R.H. Barnard & D.R. Philpott	Pearson Prentice Hall	11th Edition, 2006
2	Fundamentals Of Aerodynamics	John D. Anderson	McGraw-Hill	6th Edition, 2017
3	Aircraft Instruments and Integrated Systems	E. H. J. Pallett	Pearson Prentice Hall	3rd Edition, 1992
4	Introduction to Flight	John D. Anderson	McGraw-Hill	6th Edition, 2008
5	Fundamentals of Aerospace Navigation and Guidance	Pierre T. Kabamba	Cambridge University Press	1, 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Aerodynamics for Engineering Students	E.L. Houghton, P.W. Carpenter, Steven H. Collicott, Daniel T. Valentine	Elsevier Science	6th Edition, 2012
2	Plasma Dynamics for Aerospace Engineering	Joseph J. S. Shang	Cambridge University Press	1, 2028

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod01lec02.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod01lec03.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod05lec22.mp4
2	https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod05lec24.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod05lec26.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod05lec28.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod06lec33.mp4
3	https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod08lec41.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod09lec45.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod09lec46.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod09lec47.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod09lec48.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod11lec61.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod11lec62.mp4 https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod11lec63.mp4
4	https://archive.nptel.ac.in/content/storage2/101/101/101101079/MP4/mod10lec51.mp4

SEMESTER S7

RENEWABLE ENERGY ENGINEERING

Course Code	**PEMET754**	**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. Understanding commercial energy sources and alternatives
2. Applying the fundamentals of heat transfer in solar energy systems
3. Obtaining knowledge about energy from wind, small hydroelectric projects, ocean, biomass, hydrogen and hybrid systems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Commercial energy sources -World's production and reserves-India' Production and reserves, Energy Alternatives Principles of solar radiation: Solar radiation outside the earth's atmosphere and at the earth's surface Solar Constant, Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine	**9**
2	Solar Energy collectors: Solar thermal collectors -Flat plate collectors – Solar concentrators (Tracking concentrators and Non-tracking concentrators) Solar Energy Storage Systems –Solar thermal power plant - Principle and operation of Solar Pond Applications – Solar Photovoltaic system, Solar water heating, Solar Air heating, Solar crop drying, Solar distillation	**9**
3	Wind Energy –Classification of wind turbines – Types of rotors – Land for wind energy (regions, areas and khals) – Modes of wind power generation (Standalone mode, backup mode and Grid connected wind turbine generators)	**9**

	Smal Hydel power plants – classification and advantages	
4	Energy from ocean – Tidal power generation – Wave power generation Bio Mass Energy- Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel, Biogas production from waste biomass, factors affecting biogas generation Hydrogen Energy – various routes for production of Hydrogen energy Hybrid Energy Systems – PV hybrid with diesel generator – Wind – diesel hybrid system –Biomass – Solar thermal hybrid system	**9**

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	Differentiate between commercial energy systems and alternatives	**K2**
CO2	Obtain a detailed knowledge in solar energy implementation for collection, conversion and storage	**K2**
CO3	Understand the possibilities of wind energy and small hydel power plants	**K2**
CO4	Gain knowledge about tidal and wave energy, energy from biomass and hydrogen	**K2**
CO5	Understand about the energy alternatives by hybrid system	**K2**

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

CO-PO Mapping Table:

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Renewable Energy Resources	John Twidell, Tony Weir	Taylor and Francis	3rd Edn, 2015
2	Renewable Energy Sources and Emerging Technologies	D P Kothari, K C Singal, Rakesh Ranjan	PHI Learning Pvt. Ltd.	2nd Edn, 2014
3	Non-conventional Energy Sources	G D Rai	Khanna Publishers	2004
4	Solar Energy: Principles of Thermal Collection and			

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Sustainable Energy Choosing among options	Jefferson W Tester	PHI Learning Pvt. Ltd.	2006
2	Fundamentals and Applications of Renewable EnergyMc Graw Hill ,2019	Mehmet KanoğluYunus A. Çengel John M. Cimbala	Mc Graw Hill	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NOC | Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems (nptel.ac.in)
2	NOC | Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems (nptel.ac.in)
3	NOC | Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems (nptel.ac.in)
4	NOC | Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems (nptel.ac.in)

SEMESTER S7

MOBILE ROBOTICS

Course Code	**PEMET756**	**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. Providing a foundation to the theory behind numerical computation and optimization techniques used in robotic systems
2. This course will equip the students with mathematical framework for the robotic systems and optimization techniques necessary for mobile robotic systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Wheeled Mobile Robots, Wheeled locomotion: The design space, wheeled locomotion: Case studies. Mobile manipulators, Legged Mobile Robots- Leg configurations and stability, Examples of legged robot locomotion, aerial robots, underwater robots and surface water robots	8
2	**Kinematic model:** of a differential drive and a steered mobile robot, degree of freedom and maneuverability, Degree of steerability, different wheel configurations, holonomic and non-holonomic robots. **Dynamics of mobile robot:** Lagrange-Euler method, Newton-Euler methods, Differential-Drive WMR, Dynamics of WMR with Slip, Car-Like WMR Dynamic Model, Three-Wheel Omnidirectional Mobile Robot	10
3	**Sensors for mobile robot navigation:** Sensor classification, Characterizing sensor performance, Wheel /motor sensors, Heading sensors, Accelerometers, IMUs, Ground-based beacons, Active ranging, Motion/speed sensors, and Vision-based sensors. **Robot navigation:** Localization, Error propagation model, Probabilistic map-	9

	based localisation-Kalman method, Autonomous map building, Simultaneous localization and mapping (SLAM).	
4	**Path Planning:** local vs global path planning, Graph search, Potential field-based path planning; Map based path planning- Dijkstra's algorithm, A*, D* algorithms. Obstacle avoidance- Bug algorithm, Vector field histogram, Dynamic window approach. **Control of mobile robots:** Control of differential drive robot and steered robot based on its kinematic model, Case study- design and implementation of a differential drive robot capable of moving to a point, following a line and following a path.	**9**

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	Familiarise types of locomotion for mobile Robots	**K2**
CO2	Derive the kinematic model of mobile robots	**K4**
CO3	Derive dynamic model of mobile robots	**K4**
CO4	Choose appropriate Sensors for mobile robot navigation	**K3**
CO5	Perform navigation and path planning mobile robots	**K3**
CO6	Control the mobile robots to follow different paths	**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	3	-	3	3	3	2	-	-	-	-	-	3
CO2	3	-	3	3	3	2	-	-	-	-	-	3
CO3	3	-	3	3	3	2	-	-	-	-	-	3
CO4	3	-	3	3	3	2	-	-	-	-	-	3
CO5	3	-	3	3	3	2	-	-	-	-	-	3
CO6	3	-	3	3	3	2	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Autonomous Mobile Robots	R. Siegwart, I. R. Nourbakhsh,	The MIT Press,	2011
2	Robotics, Vision and Control: Fundamental Algorithms in MATLAB,	Peter Corke,	Springer Tracts in Advanced Robotics	2011
3	Introduction to Mobile Robot Control,	Spyros G. Tzafestas	Elsevier.	
4	Planning Algorithms	S. M. La Valle	Cambridge University Press	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probabilistic Robotics.	Thrun, S., Burgard,W., and Fox, D.,	MIT Press, Cambridge, MA,	2005
2	Arduino and Kinect Projects: Design, Build	Melgar, E. R., Diez, C. C	Blow Their Minds,.	2012
3	Introduction to Autonomous Mobile Robots	Siegwart, Roland,	Cambridge, Mass.: MIT Press,	Second Edition,

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/106/112106298/
2	https://archive.nptel.ac.in/courses/112/106/112106298/
3	https://archive.nptel.ac.in/courses/112/106/112106298/
4	https://archive.nptel.ac.in/courses/112/106/112106298/

SEMESTER S7

FLEXIBLE MANUFACTURING SYSTEMS

Course Code	**PEMET757**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	**Course Type**	Theory

Course Objectives:

1. Understand the basic components, layout configurations, and functions of Flexible Manufacturing Systems (FMS).

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction**: Evolution of FMS, Basic Components of FMS, Types of FMS Layouts, -Inline layout, loop layout, loader layout, open field layout, robot configured layout, general FMS considerations, functions of FMS, FMS Justification, Cell/FMS Justification Flow chart.	**9**
2	Manufacturing cells: Introduction, Classification of manufacturing Cells- FMS Unattended Machining- Features and Requirement, Toyota Production System (TPS), Group technology- Part Classification and Coding, Production Flow Analysis. Machining Center- Types, Axes and Format Information, Automated Features and Capabilities of Machining Center, Cellular Vs Flexible manufacturing.	**9**
3	Computer aided programme generation & Product Manufacturing, Automated Material Movement and Storage System- Automated Storage and Retrieval Systems (AS/RS), Industrial Robots, Cutting Tools and Tool Management- Tool Preset, Identification and Data Transfer.	**9**
4	FMS Planning: CAD Considerations FMS planning, CAM Considerations for FMS planning. FMS Software Structure- General Structure and Requirements, Types of FMS Software Modules, FMS installation and	**9**

	implementation- System Installation, acceptance testing.	

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 basic components, layout configurations, and functions of Flexible Manufacturing Systems (FMS).	K2
CO2	Remember the classification of manufacturing cells, features and requirements of unattended machining, and principles of the Toyota Production System (TPS).	K1
CO3	Apply the knowledge of CAD and CAM considerations in planning and implementing FMS.	K3
CO4	Understand the automated material movement, storage systems, and tool management in FMS operations.	K2

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

CO-PO Mapping Table:

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Flexible Manufacturing System	Shivanand H.K., Benal MM, Koti V	New age international (P) Limited, New Delhi	2006
2	Flexible Manufacturing Cells and System	William W Luggen	Prentice Hall of Inc New Jersey	1991
3	Flexible Manufacturing system	Reza A Maleki	Prentice Hall of Inc New Jersey	1991
4	Flexible Manufacturing	. John E Lenz D. Eppinger	marcel Dekker Inc New York	1989

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Manufacturing Engineering and Technology	Kalpakjin	Addison Wesley Publishing	1995
2	Automation, Production Systems and Computer Integrated Manufacturing"	Mikell P. Groover	PHI,	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/106/110106044/
2	https://archive.nptel.ac.in/courses/110/106/110106044/
3	https://archive.nptel.ac.in/courses/110/106/110106044/
4	https://archive.nptel.ac.in/courses/110/106/110106044/

SEMESTER S7

QUALITY ENGINEERING AND MANAGEMENT

Course Code	**PEMET758**	**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 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)- he TQM axioms - Consequences of total quality- Barriers to TQM, Deming approach, Juran's quality trilogy, Crosby's fourteen steps for quality improvement.	9
2	**Human dimensions of TQM** – Top management commitment- Leadership for TQM- Change management- resources for quality activities - Training for quality –Employee involvement, motivation, empowerment- teamwork- self managing teams - Role of the quality director-Quality System: ISO 9000 family of standards. Quality auditing- types and benefits.	9
3	**Tools and Techniques in TQM**: Affinity diagram -brainstorming - cause and effect analysis - process flow chart – check sheets- Scatter diagram - 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.	9

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.	**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	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 S7

OPTIMIZATION TECHNIQUES

Course Code	PEMET755	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Formulate and classify different optimization problems.
2. Apply classical, numerical and modern methods for solving optimization problems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Engineering applications of optimization, Formulation of design problems as mathematical programming problems. Classification of optimization problems/techniques. Classical optimization: unconstrained single and multivariate optimization, Constrained optimization. Linear, Mathematical formulation of LP Problems, Solving using Simplex method and Graphical method.	9
2	Game Theory: Introduction, 2- person zero – sum game -Saddle point; Mini-Max and Maxi-Min Theorems (statement only)- Graphical solution (2x n, m x 2 game), dominance property. Introduction to network tree - Minimal Spanning Tree - Prim's Algorithm. Shortest path problems- Solution methods – Dijkstra's Method.	9
3	Single variable optimization methods- Fibonacci search method, Newton Raphson method Multi-variable methods- Hook-Jeeves pattern search method, Cauchy's	9

	(steepest descent) method	
4	Introduction to Genetic algorithm, Basic GA framework, GA operators: Encoding, Crossover, Selection, Mutation Introduction to Fuzzy logic. Fuzzy sets and membership functions. Operations on Fuzzy sets. Optimization of Fuzzy Systems.	**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	Formulate the real world problem as Linear Programming Problem	**K4**
CO2	Apply different methods of Game Theory, Network Tree and Shortest Path.	**K3**
CO3	Find solutions for Nonlinear unconstrained optimization problems	**K3**
CO4	Apply modern methods of optimization for solving optimization problems.	**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	3	3	-	-	-	-	-	-	-	-	-	2
CO2	3	3	-	-	-	-	-	-	-	-	-	2
CO3	3	3	-	-	-	-	-	-	-	-	-	2
CO4	3	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	Engineering Optimization : Theory and Practice	S.S.Rao	New Age International Publishers, New Delhi	Revised 3rd Edition 2011
2	Operations Research	H.A. Taha	Pearson	Eight Edition 2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Operations Research	Kanti Swarup, P.K.Gupta and Man Mohan	Sultan Chand and Sons	20th Revised Edition 2022
2	Optimization for Engineering Design- Algorithms and Examples	Kalynamoy Deb.	Prentice-Hall of India Pvt. Ltd., New Delhi	2nd Edition 2012
3	Operations Research – Principles andPractice	A. Ravindran, D. T. Phillips, J. J. Solberg	John Wiley and Sons.	2nd Edition 2007

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/111/105/111105039/

SEMESTER S7

ENGINEERING MATERIALS

Course Code	OEMET721	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)	NA	Course Type	Theory

Course Objectives:

1. To provide a comprehensive understanding of the classification, structure, and properties of different engineering materials, including metals, ceramics, polymers, and composites.
2. To develop the ability to select metals and their alloys for specific engineering applications based on their properties and performance requirements.
3. To introduce polymeric, ceramic, and composite materials, and discuss their unique properties, synthesis methods, and applications in modern engineering.
4. To develop the ability to select appropriate materials for specific engineering applications based on their properties and performance requirements.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Engineering Materials:** Overview of Engineering Materials: Definition and Classification, Importance in Engineering Design. Material Properties; Mechanical Properties: Strength, Toughness, Ductility, Hardness. Thermal Properties: Conductivity, Expansion, Heat Capacity, Electrical and Magnetic Properties. Material Selection Criteria: Factors Influencing Material Selection, Case Studies in Material Selection Material Testing and Standards: Overview of Material Testing Methods, Introduction to ASTM, ISO, and other relevant standards Material Processing: Basic Processing Techniques: Casting, Forging, Machining, Introduction to Manufacturing Processes: Additive Manufacturing, Powder Metallurgy.	11

2	**Introduction to Metals:** Types of Metals: Ferrous and Non-Ferrous, Crystal Structures and Properties. Steel and Its Alloys: Composition and Heat Treatment, Types of Steel: Carbon Steel, Alloy Steel, Stainless Steel. Non-Ferrous Metals and Alloys: Aluminum, Copper, Titanium, Nickel Alloys. Applications and Properties, Corrosion and Protection: Mechanisms of Corrosion, Methods of Corrosion Control and Prevention	**9**
3	**Polymers and Composites** Introduction to Polymers: Types of Polymers: Thermoplastics, Thermosets, Elastomers, polymerization Methods. Properties and Applications of Polymers: Mechanical and Thermal Properties, Case Studies in Polymer Applications Composite Materials: Definition and Types of Composites, Fiber-Reinforced Composites: Properties and Applications, Manufacturing Techniques **Ceramics and Glasses** Introduction to Ceramics: Types of Ceramics: Traditional and Advanced Ceramics. Properties: Hardness, Brittleness, Wear Resistance Processing of Ceramics. Methods of Shaping and Sintering, Glazing and Surface Treatments Glasses: Types of Glasses: Soda-Lime, Borosilicate, Specialty Glasses, Properties and Applications, Applications in Engineering Structural Ceramics Electronic and Optical Ceramics	**10**
4	**Material Testing and Characterization** Mechanical Testing Methods: Tensile, Compression, Impact, and Fatigue Testing, Microscopy and Surface Analysis, Optical Microscopy, Scanning Electron Microscopy (SEM), Surface Profiling Techniques Non-Destructive Testing (NDT)Techniques: Ultrasonic Testing, Radiographic Testing, Magnetic Particle Testing Material Behavior and Failure Analysis Fracture Mechanics and Failure Analysis Case Studies in Material Failures	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To provide a comprehensive understanding of the classification, structure, and properties of different engineering materials, including metals, ceramics, polymers, and composites.	**K1. K2**
CO2	To develop the ability to select metals and their alloys for specific engineering applications based on their properties and performance requirements.	**K1, K2**
CO3	To introduce polymeric, ceramic, and composite materials, and discuss their unique properties, synthesis methods, and applications in modern engineering.	**K3, K4**
CO4	To develop the ability to select appropriate materials for specific engineering applications based on their properties and performance requirements.	**K3, 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	2	2	-	-	-	-	-	-	-	-	2
CO2	3	2	2	-	-	-	-	-	-	-	-	2
CO3	3	2	2	-	-	-	-	-	-	-	-	2
CO4	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	Materials Science and Engineering: An Introduction	William D. Callister Jr. and David G. Rethwisch	John Wiley	10th edition, 2020
2	EngineeringMaterials:Properties and Selection	Kenneth G. Budinski and Michael K. Budinski	Pearson India	9th edition, 2017
3	Introduction to Materials Science for Engineers,	James F. Shackelford	Pearson India	9th edition, 2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Science and Engineering of Materials	Donald R. Askeland	Chapman & Hall	1996
2	Materials Science and Engineering: A First Course	V. Raghavan	PHI Learning	6th edition 2015

SEMESTER S7

ROBOTICS

Course Code	OEMET722	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. This course helps the student to the basic idea of Robots. Students are introduced to the basic design considerations of robots.
2. Concepts like trajectory planning and obstacle avoidance and kinematics of robots are introduced.
3. Discussion on various mobile robots and robotic manipulators are also included as part of the course to get an overall idea on robotics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots. Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers.	9
2	Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous coordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (up to 3DOF). Inverse kinematics- general properties of solutions and problems (up to	10

	3DOF).	
3	Manipulator Dynamics: Lagrange's formulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots up to 2 DOF, modelling including motor and gearbox.	**8**
4	Trajectory Planning. Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, point-to-point vs. continuous path planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms. Robot Control: The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque 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	Familiarise with anatomy, specifications and types of Robots	**K2**
CO2	Obtain forward and inverse kinematic models of robotic manipulators	**K3**
CO3	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion	**K4, K5**
CO4	Develop a dynamic model and design the controller for robotic manipulators	**K4, K6**
CO5	Choose the appropriate Robotic configuration and list the technical specifications for robots used in different application	**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	2	1	-	-	-	-	-	-	-	-	-	3
CO2	2	1	-	-	-	-	-	-	-	-	-	3
CO3	2	1	-	-	-	-	-	-	-	-	-	3
CO4	3	2	2	-	-	-	-	-	-	-	-	3
CO5	3	2	2	-	-	-	-	-	-	-	-	3

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Robotics – Analysis and Control	Robert. J. Schilling	Prentice Hall of India	1996
2	Introduction to Robotics (Mechanics and Control)	John. J. Craig	Pearson Education Asia	2002
3	Introduction to Robotics	S K Saha,	McGraw Hill Education	
4	Robotics and Control	R K Mittal	Tata McGraw Hill, New Delhi	2003
5	Robotics-Fundamental concepts and analysis	AshitavaGhosal	Oxford University Press	
6	Robotics Technology and Flexible Automation,	S. R. Deb		Second Edition,
7	Introduction to Autonomous Mobile Robots	Siegwart, Roland,	Cambridge, Mass.: MIT Press,	Second Edition,

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Robotics	Siciliano, Khatib	Springer	
2	Introduction to Robotics – Mechanics and Control	John J. Craig		
3	Modern Robotics Mechanics, Planning and Control	. Kevin M. Lynch, Frank C. Park,		
4	Robotics Modelling, Planning and Control	Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo	Springer	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/105/112105249/
2	https://archive.nptel.ac.in/courses/112/105/112105249/
3	https://archive.nptel.ac.in/courses/112/105/112105249/
4	https://archive.nptel.ac.in/courses/112/105/112105249/

SEMESTER S7

FINITE ELEMENT METHODS

Course Code	**OEMET723**	**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 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. Convergence requirement of shape functions, Pascal triangle.	**9**
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,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.	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To understand the governing equations of 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:

	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									

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	McGrawHillEducation	ThirdEdition,2009
2	Concept and application of Finite Element method	Robert D Cook	Wiley	ThirdEdition,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	ThirdEdition,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 S7
NON – DESTRUCTIVE TESTING

Course Code	**OEMET724**	**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. **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 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	9

	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. **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.	**11**
4	**Advanced NDT 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 S7

ENGINEERING INSTRUMENTS AND MEASUREMENTS

Course Code	**OEMET725**	**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)	Nil	**Course Type**	Theory

Course Objectives:

1. Introduce the significance and need for mechanical measurements and inspection
2. To learn various measurement techniques, innovations, refinements.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction: Significance of Mechanical Measurements, Need of Inspection, Classification of measuring instruments, generalized measurement system, Types of inputs, Static characteristics & Dynamic characteristics. Errors in measurement and data analysis, Statistical analysis of data	**9**
2	Displacement measurement: Transducers for displacement measurement – Potentiometers, LVDT, Capacitance type, Digital transducers, Nozzle Flapper transducer. Measurement of Surface Characteristics: Measurement of straightness, flatness, squareness, parallelism etc., measurement of surface finish Strain measurement: Theory of strain gauges, gauge factor, Temperature compensation, Bridge circuit, Orientation of strain gauges for force and torque measurement, Strain gauge-based load cells and torque sensors	**9**
3	Force measuring devices: Torque and shaft power measurement, Basic method of force measurements, elastic force transducers, torque measurement on rotating shaft, shaft power measurement. Pressure measuring devices: Air micro manometers, sonar manometers, low pressure gauges such as McLeod gauge, Thermal conductivity gauge, Pirani gauge, Ionization Gauge, Piezo-electric pressure transducers, Elastic	**9**

	Transducers, Force balance Transducers. Dead weight gauges, elastic transducers and force balance transducer.	
4	Flow measurement: Gross flow rate measuring meters, constant area , variable pressure drop meters, local flow velocity magnitude and direction meters, hot wire anemometer velometer Temperature measurement: Measurement of temperature by liquid - in - glass thermometers, pressure thermometers, thermocouples, their calibration, resistance thermometer, Bi metallic thermometer, thermistors, radiation and optical pyrometers.	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To identify and classify different measuring instruments and their static and dynamic characteristics, ensuring proper selection and usage for various engineering applications	**K2**
CO2	To measure and analyse displacement, strain and surface characteristics using appropriate techniques and devices, ensuring quality control and performance optimization in manufacturing and engineering processes	**K3**
CO3	To examine various devices to measure force, pressure accurately using a variety of devices and techniques	**K5**
CO4	To acquire the ability to measure flow and temperature and enabling them to address complex engineering challenges in these areas effectively.	**K4**
CO5	To select measurement system for engineering applications	**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	3	-	-	3	2	-	-	-	-	-	-	-
CO2	3	3	3	-	2	-	-	-	-	-	-	-
CO3	3	3	-	3	2	-	-	-	-	-	-	-
CO4	3	-	-	3	1	-	-	-	-	-	-	-
CO5	3	-	3	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Measurement Systems (Applications and Design)	E.O.Dobelin	McGraw Hill	4th, 1990
2	Mechanical Measurements and Instrumentation & Control	A.K. Sawhney & Puneet Sawhney	Dhanpat Rai & Co	12th 2009.
3	Instrumentation Measurement and Analysis	B.C. Nakra and K.K. Chaudhry	Tata McGraw Hill	3rd 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering metrology and Measurements	N.V. Raghavendra	Oxford University press	2013
2	A Text Book of Engineering Metrology	R.K.Jain	Khanna Publishers,Delhi	2022
3	Mechanical Measurement and Control	D.S Kumar	Metropolitan Publication	2012
4	Industrial Instrumentation and Control	S. K. Singh	McGraw Hill Education (India)	2009
5	Mechanical Measurements and Instrumentation	R. K. Rajput	S K Kataria & Sons,	2006

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107242
2	http://en.wikipedia.org/wiki/Metrology
3	https://youtu.be/ioyRjm-dSuI
4	https://youtu.be/V1qrHvMs8tE
5	https://archive.nptel.ac.in/courses/112/104/112104250
6	https://nptel.ac.in/courses/112106138

SEMESTER S7

COMPUTATIONAL HEAT TRANSFER

Course Code	**OEMET726**	**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 Fluid mechanics and heat transfer	**Course Type**	Theory

Course Objectives:

1. To familiarize students with basic understanding of fluid flow and heat transfer.
2. To understand how to model simple heat transfer problems in one and two dimensions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basics of Heat Transfer-Conduction, convection and radiation heat transfer. Mathematical description of fluid flow and heat transfer: conservation equations for mass, momentum, energy and chemical species in Cartesian and cylindrical coordinates. Classification of Partial differential equations – elliptic, parabolic and hyperbolic equations. Initial and boundary conditions	**9**
2	Finite difference form of PDE equations-Taylor's series approach. Central difference, backward difference, and forward difference of first and second order derivatives. Solution of Laplace equation (conduction problems) using finite difference equations. Discretization error, truncation error, round off error, Convergence of iteration.	**9**
3	Solution of unsteady conduction equation using finite difference method-Explicit, implicit and semi-implicit methods. Stability of numerical solutions. Solution of linear algebraic equations- direct methods and indirect methods. Point by point iterations, Tri diagonal matrix method (TDMA)	**9**

4	Introduction to Finite volume method. Solution of one-dimensional steady state conduction problems. Handling different boundary conditions. Solution of one-dimensional convection diffusion problems using central difference schemes and upwind scheme. Introduction to SIMPLE algorithm for incompressible flows.	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To understand the basics of governing equations of fluid flow and heat transfer	**K2**
CO2	To understand PDE equations and its classification.	**K2**
CO3	To familiarize with numerical techniques like FDM and FVM	**K1**
CO4	To understand various methods to solve system of linear algebraic equations	**K2**
CO5	To solve simple problems of steady and unsteady conduction using numerical techniques.	**K3**

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

CO-PO Mapping Table:

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introductory methods to numerical analysis	S S Sastry	PHI learing Private Ltd.	2012
2	Numerical Heat Transfer and Fluid Flow	Suhas V Patankar	Crc Press	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computational fluid dynamics	Anderson, John David and Wendt, John	McGraw-Hill International Editions: Mechanical Engineering	1995
2	An Introduction to Computational Fluid Dynamics the Finite Volume Method	H. Veersteg W. Malalasekra	Pearson; 2nd edition (1 January 2008); Pearson India	2008
3	Heat transfer	S P Venkatesh	Ane books Pvt Ltd	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1- 4	https://archive.nptel.ac.in/courses/112/108/112108091

SEMESTER S7

POWER PLANT ENGINEERING

Course Code	OEMET727	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.	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. **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.	**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**
CO 5	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:

	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

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/