SEMESTER 3

MECHANICAL ENGINEERING

SEMESTER S3
MATHEMATICS FOR ELECTRICAL SCIENCE AND PHYSICAL SCIENCE – 3

(Common to B & C Groups)

Course Code	**GYMAT301**	**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 in complex numbers.	**Course Type**	Theory

Course Objectives:

1. To introduce the concept and applications of Fourier transforms in various engineering fields.
2. To introduce the basic theory of functions of a complex variable, including residue integration and conformal transformation, and their applications

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	Fourier Integral, From Fourier series to Fourier Integral, Fourier Cosine and Sine integrals, Fourier Cosine and Sine Transform, Linearity, Transforms of Derivatives, Fourier Transform and its inverse, Linearity, Transforms of Derivative. **(Text 1: Relevant topics from sections 11.7, 11.8, 11.9)**	**9**
2	Complex Function, Limit, Continuity, Derivative, Analytic functions, Cauchy-Riemann Equations (without proof), Laplace's Equations, Harmonic functions, Finding harmonic conjugate, Conformal mapping, Mappings of $w= z^2$, $w=e^z$, $w=\frac{1}{z}$, $w= \sin z$. **(Text 1: Relevant topics from sections 13.3, 13.4, 17.1, 17.2, 17.4)**	**9**
3	Complex Integration: Line integrals in the complex plane (Definition & Basic properties), First evaluation method, Second evaluation method, Cauchy's integral theorem (without proof) on simply connected domain, Independence of path, Cauchy integral theorem on multiply connected domain (without proof), Cauchy Integral formula (without proof). **(Text 1: Relevant topics from sections 14.1, 14.2, 14.3)**	**9**

4	Taylor series and Maclaurin series, Laurent series (without proof), Singularities and Zeros – Isolated Singularity, Poles, Essential Singularities, Removable singularities, Zeros of Analytic functions – Poles and Zeros, Formulas for Residues, Residue theorem (without proof), Residue Integration- Integral of Rational Functions of $cos\theta$ and $sin\theta$. **(Text 1: Relevant topics from sections 15.4, 16.1, 16.2, 16.3, 16.4)**	**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	Determine the Fourier transforms of functions and apply them to solve problems arising in engineering.	**K3**
CO2	Understand the analyticity of complex functions and apply it in conformal mapping.	**K3**
CO3	Compute complex integrals using Cauchy's integral theorem and Cauchy's integral formula.	**K3**
CO4	Understand the series expansion of complex function about a singularity and apply residue theorem to compute real integrals.	**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	-	-	-	-	-	-	-	2
CO2	3	3	-	2	-	-	-	-	-	-	-	2
CO3	3	3	-	2	-	-	-	-	-	-	-	2
CO4	3	3	-	2	-	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Advanced Engineering Mathematics	Erwin Kreyszig	John Wiley & Sons	10th edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Complex Analysis	Dennis G. Zill, Patrick D. Shanahan	Jones & Bartlett	3rd edition, 2015
2	Higher Engineering Mathematics	B. V. Ramana	McGraw-Hill Education	39th edition, 2023
3	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	44th edition, 2018
4	Fast Fourier Transform - Algorithms and Applications	K.R. Rao, Do Nyeon Kim, Jae Jeong Hwang	Springer	1st edition, 2011

SEMESTER S3

MECHANICS OF SOLIDS

Course Code	PCMET302	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory

Course Objectives:

1. To acquaint with the basic concepts of stress and deformation in solids.
2. To practice the methodologies to analyse stresses and strains in simple structural members, and to apply the results in simple design problems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to analysis of deformable bodies. Types of external loads - Normal, Shear, Bending and Bearing stress- Linear and Shear strains. Hooke's law - Stress-Strain diagrams - concepts of Isotropy, Orthotropy, Anisotropy. Young's Modulus, Bulk Modulus and Rigidity Modulus. Poisson's ratio - Relationship between elastic constants. Deformation in axially loaded bars –uniform cross section, varying cross section, dissimilar materials, principle of superposition. Thermal effects – simple, composite bars.	11
2	Torsion: Shafts - torsion theory of elastic circular bars – assumptions and limitations – polar modulus - torsional rigidity – shaft design for torsional load. Beams- Classification - Diagrammatic conventions for supports and loading Differential equations between load, Shear Force and Bending Moment- Shear Force and Bending Moment Diagrams of Cantilever and Simply supported beam with Point load/UDL. Point of Inflection.	11

3	Stresses in Beams: Pure Bending – Flexure formula for beams - assumptions and limitations – Section Modulus - Flexural Rigidit - derivation and problems for rectangular section only -assumptions and limitations Deflection of Beams: Moment-Curvature relation – assumptions and limitations - Double Integration method – Macaulay's method	**11**
4	Stress on an inclined plane due to Uniaxial stress- Stress on an inclined plane due to Biaxial stress- Stress on an inclined plane due to two Normal Stresses accompanied by Shear stresses- principal planes and stresses. Mohr's circle of stress. Buckling and stability of long columns-Euler's buckling/crippling load for columns with different end conditions- Euler equation derivation for both ends hinged only- Rankine's formula	**11**

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	Determine the stresses and strains in deformable bodies subjected to different types of external loads and thermal effects	**K3**
CO2	Analyse the torsion of circular bars and draw the shear force and bending moment diagrams for beams	**K4**
CO3	Determine the stresses and deflections in beams subjected to transverse loads	**K3**
CO4	Determine analytically and graphically the principal stresses and planes for structural members subjected to loads and analyse the strength of columns	**K4**

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									
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	Mechanics of Solids	R.K.Bansal	Laxmi Publications	2012
2	Mechanics of Solids	S. S. Bhavikatti	New Age International	2013
3	Strength of Materials	Surendra Singh	S. K. Kataria & Sons	2013
4	Strength of Materials	Rattan	McGraw Hills	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mechanics of materials	R. C. Hibbeler	Pearson Higher Education	2018
2	Engineering Mechanics of Solids	Popov E	PHI	2002
3	Mechanics of Materials	Beer & Johnston	McGraw Hills	2017
4	Mechanics of Materials	Pytel A. and Kiusalaas J.	Cengage Learning India Private Limited,	2015

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_ce46/preview
2	https://onlinecourses.nptel.ac.in/noc22_ce46/preview
3	https://onlinecourses.nptel.ac.in/noc22_ce46/preview
4	https://onlinecourses.nptel.ac.in/noc22_ce46/preview

SEMESTER S3
FLUID MECHANICS AND MACHINERY

Course Code	**PCMET303**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To establish fundamental knowledge of basic fluid mechanics and its simple applications.
2. To familiarize students with the relevance of turbo machines and find solutions to the associated engineering problems.

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	Prerequisite: Properties of fluid: Specific gravity, Specific Weight, Specific Volume, Dynamic and Kinematic Viscosity. Introduction to fluid mechanics - Types of fluids, Newton's law of viscosity. Pressure Measurement: Fluid pressure, Pressure head, types of pressures. Piezometer, Simple, differential Manometers. Fluid statics: Pressure, density, height relationship. Hydrostatic force and pressure on plane and inclined surfaces, Centre of pressure. Buoyancy and Metacentre. Stability of immersed and floating bodies.	**8**
2	Fluid kinematics: Description of fluid motion – Types of flows, Material derivative velocity and acceleration – Streamlines, path lines and streak lines, Stream function and velocity potential function, flow net . Fluid dynamics: Continuity equation, Euler's, and Bernoulli's equations. – Measuring instruments – Pitot tube, Orificemeter, Venturimeter, Rectangular and Triangular Notches-(notches Problems not required).	**8**

3	Pipe flow – laminar and turbulent flows, significance of Reynolds number, shear stress and velocity distribution in a pipe flow.– Hagen-Poiseullie equation, Darcy-Weisbach equation and Chezy's equation , Moody's chart for estimating frictional losses, Major and minor energy losses, hydraulic gradient, and total energy line. Navier-Stokes equation and explanation (without proof) . Dimensional analysis using Buckingham's π theorem. Boundary layer theory: Qualitative comparison between laminar and turbulent boundary layer. Boundary layer separation	**12**
4	Impact of jets: Impact of jet on fixed vertical, moving vertical flat plates. Impact of jet on curved vanes – fixed and moving. Velocity triangles. Classification of Turbines and pumps Comparison and examples. Pelton, Francis and Kaplan Turbines: Principle and working, head, work done, efficiencies (Problems using velocity triangles not required). Centrifugal Pumps: Principle and working, head, work required, efficiencies, Priming and cavitation.(Problems using velocity triangles not required) . Reciprocating Pump: Principle and working – slip,negative slip, work required and efficiency.	**12**

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	Identify the fundamental fluid properties, their relationships and apply them to estimate the fluid pressure and hydrostatic forces on bodies	**K3**
CO2	Classify the fluid flow and apply the principles kinematic and dynamics using the conservation of mass and momentum equations.	**K3**
CO3	Analyse viscous flow through pipes and estimate the major and minor losses associated with piping network.	**K3**
CO4	Understand the basic concept of dimensional analysis.	**K3**
CO5	Select suitable turbo machine for specific application by identifying the pertinent parameters	**K3**

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

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

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

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

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fluid Mechanics	Cengel Y. A. and J. M. Cimbala	Tata McGraw Hill	2013
2	Introduction to Fluid Mechanics and Fluid Machines	Som S.K.	McGraw Hill Education India	2011
3	Fluid Mechanics and Hydraulic Machines	Bansal R.K.	Laxmi Publications	2005

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fluid Mechanics	White F.M.	Tata McGraw Hill	2003
2	Engineering applications of Fluid dynamics	Fisher and Henly	Willford Press	2023

Video Links (NPTEL, SWAYAM…)	
Module No.	Link ID
1	Fluid Statics https://www.youtube.com/watch?v=rY7bvZn75Do&list=PLwdnzlV3ogoWrAmpEcsPXayfsXnFfYY1O&index=4 Bouyancy, Metacentre and stability https://www.youtube.com/watch?v=gMuucNxc7eI&list=PLwdnzlV3ogoV-ATGY2ptuLS9mwLFOJoDw&index=7&pp=iAQB
2	Fluid kinematics https://www.youtube.com/watch?v=rY7bvZn75Do&list=PLwdnzlV3ogoWrAmpEcsPXayfsXnFfYY1O&index=4
3	Internal Viscous Flow https://www.youtube.com/watch?v=qLx7ip0eBps&list=PLCoE5wxWtHFYiVGswvsWRaHjv18vxZzE2&index=17
4	Introduction to turbomachines https://www.youtube.com/watch?v=ocVzrn4DLj8&list=PLbMVogVj5nJQQp3QLuzbcHrt0XncZZTiE&index=2

SEMESTER S3

MANUFACTURING PROCESSES

Course Code	**PBMET304**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To gain theoretical and practical knowledge in manufacturing processes and to develop and understanding of the dependent and independent variables which control a production processes.
2. Provide a detailed discussion on the welding process and the physics of welding. Introduce students to different welding processes weld testing and advanced processes to be able to appreciate the practical applications of welding.
3. Generate solutions to problems that may arise in manufacturing engineering

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	General Classification of Manufacturing Processes. Casting-Characteristics of sand, design of patterns, cores, chaplets, solidification of metals and Chvorinov's rule, elements of gating system, risers, chills, numerical problems, defects in castings. Special casting process- Shell moulding, precision investment, die casting, centrifugal casting, continuous casting and squeeze casting. Powder Metallurgy- Powder Production, powder characteristics, mixing, compaction methods, sintering.	9
2	Welding: Classification, Fusion and Solid-state welding processes Gas Welding - Oxyacetylene welding-chemistry, types of flame and its applications	9

	Arc welding- applications, process parameters, numerical problems, consumable and non-consumable arc welding, SMAW; GTAW; GMAW; SAW; AHW; PAW. Thermit welding, friction welding, electro slag welding, ultrasonic welding, electron beam welding, laser beam welding Resistance welding-applications, process parameters, numerical problems Heat Affected Zone, weldability of ferrous and non-ferrous metals, residual stresses and distortion, defects in welding Brazing - soldering - adhesive bonding	
3	Metal Forming: Plastic deformation and yield criteria − hot and cold working processes Rolling- Flat-rolling process, rolling force and power, numerical problems, types of rolling mills, rolling defects, miscellaneous rolling processes. Sheet metal operations- Press tool operations-Shearing, Tension, Compression, Tension and compression operations, applications, numerical problems. Types of die-Progressive dies, Compound dies, and Combination dies	**9**
4	Forging-Forging load, numerical problems, Various methods, applications, defects in forging - Wire, Rod, and tube drawing - mechanics of rod and wire drawing,drawing force and power, numerical problems, drawing defects – Deep drawing. Bending – Details of bending, Determination of work load, estimation of spring back, numerical problems. Extrusion- Metal flow, mechanics of extrusion, numerical problems, miscellaneous processes, defects in extrusion, applications	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16marks)**	• Each question carries 6 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Classify different techniques of casting	**K2**
CO2	Summarize powder metallurgy processes	**K2**
CO3	Categorize welding processes according to welding principles and materials.	**K2**
CO4	Determine forming load associated with rolling, forging, drawing, extrusion, and sheet metal forming	**K3**
CO5	Develop products, processes or technologies for socially relevant applications.	**K3, K4, K5**

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										
CO3	3	2										
CO4	3	3										
CO5	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	Manufacturing Science	Amitabha Ghosh Asok Kumar Mallik	Affiliated East-West Private Limited	2nd Edition 2010
2	Manufacturing Engineering and Technology	SeropeKalpakjian Steven R. Schmid	Pearson	
3	Manufacturing Technology Volume -1	P N Rao	Tata McGraw Hill	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	American Society for Metals - ASM Metals Handbook, Vol. 14	Joseph R. Davis, S. L. Semiatin,	Forming and Forging ASM International	1989
2	Tool design	Donalson cyril, LeCain, Goold, Ghose:-	McGraw Hill	
3	Cold and Hot Forging Fundamentals and Applications	Taylan Altan, Gracious Ngaile, Gangshu Shen	ASM International	2004
4	Foundry Technology	Peter Beeley	Butterworth-Heinemann	

PBL Course Elements

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

Assessment and Evaluation for Project Activity

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

Project Assessment and Evaluation criteria (30 Marks)

1. **Project Planning and Proposal (5 Marks)**

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

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

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

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

- Active participation and individual contribution
- Teamwork and collaboration

4. Execution and Implementation (10 Marks)

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

5. Final Presentation (5 Marks)

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

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

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

SEMESTER S3

INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Course Code	GNEST305	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Demonstrate a solid understanding of advanced linear algebra concepts, machine learning algorithms and statistical analysis techniques relevant to engineering applications, principles and algorithms.
2. Apply theoretical concepts to solve practical engineering problems, analyze data to extract meaningful insights, and implement appropriate mathematical and computational techniques for AI and data science applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to AI and Machine Learning**: Basics of Machine Learning - types of Machine Learning systems-challenges in ML- Supervised learning model example- regression models- Classification model example- Logistic regression-unsupervised model example- K-means clustering. Artificial Neural Network- Perceptron- Universal Approximation Theorem (statement only)- Multi-Layer Perceptron- Deep Neural Network- demonstration of regression and classification problems using MLP.(Text-2)	11
2	**Mathematical Foundations of AI and Data science**: Role of linear algebra in Data representation and analysis – Matrix decomposition- Singular Value Decomposition (SVD)- Spectral decomposition- Dimensionality reduction technique-Principal Component Analysis (PCA). (Text-1)	11
3	**Applied Probability and Statistics for AI and Data Science**: Basics of probability-random variables and statistical measures - rules in probability- Bayes theorem and its applications- statistical estimation-Maximum	11

	Likelihood Estimator (MLE) - statistical summaries- Correlation analysis- linear correlation (direct problems only)- regression analysis- linear regression (using least square method) (Text book 4)	
4	**Basics of Data Science**: Benefits of data science-use of statistics and Machine Learning in Data Science- data science process - applications of Machine Learning in Data Science- modelling process- demonstration of ML applications in data science- Big Data and Data Science. (For visualization the software tools like Tableau, PowerBI, R or Python can be used. For Machine Learning implementation, Python, MATLAB or R can be used.)(Text book-5)	**11**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply the concept of machine learning algorithms including neural networks and supervised/unsupervised learning techniques for engineering applications.	**K3**
CO2	Apply advanced mathematical concepts such as matrix operations, singular values, and principal component analysis to analyze and solve engineering problems**.**	**K3**
CO3	Analyze and interpret data using statistical methods including descriptive statistics, correlation, and regression analysis to derive meaningful insights and make informed decisions.	**K3**
CO4	Integrate statistical approaches and machine learning techniques to ensure practically feasible solutions in engineering contexts.	**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								
CO2	3	3	3	3								
CO3	3	3	3	3								
CO4	3	3	3	3								
CO5	3	3	3	3								

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Linear Algebra	Gilbert Strang	Wellesley-Cambridge Press	6th edition, 2023
2	Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow	Aurélien Géron	O'Reilly Media, Inc.	2nd edition,2022
3	Mathematics for machine learning	Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong	Cambridge University Press	1st edition. 2020
4	Fundamentals of mathematical statistics	Gupta, S. C., and V. K. Kapoor	Sultan Chand & Sons	9th edition, 2020
5	Introducing data science: big data, machine learning, and more, using Python tools	Cielen, Davy, and Arno Meysman	Simon and Schuster	1st edition, 2016

Reference Books				
1	Data science: concepts and practice	Kotu, Vijay, and Bala Deshpande	Morgan Kaufmann	2nd edition, 2018
2	Probability and Statistics for Data Science	Carlos Fernandez-Granda	Center for Data Science in NYU	1st edition, 2017
3	Foundations of Data Science	Avrim Blum, John Hopcroft, and Ravi Kannan	Cambridge University Press	1st edition, 2020
4	Statistics For Data Science	James D. Miller	Packt Publishing	1st edition, 2019
5	Probability and Statistics - The Science of Uncertainty	Michael J. Evans and Jeffrey S. Rosenthal	University of Toronto	1st edition, 2009
6	An Introduction to the Science of Statistics: From Theory to Implementation	Joseph C. Watkins	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.math.arizo	Preliminary Edition.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/106/106106198/
2	https://archive.nptel.ac.in/courses/106/106/106106198/ https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/resources/lecture-29-singular-value-decomposition/
3	https://ocw.mit.edu/courses/18-650-statistics-for-applications-fall-2016/resources/lecture-19-video/
4	https://archive.nptel.ac.in/courses/106/106/106106198/

SEMESTER S3

ECONOMICS FOR ENGINEERS

(Common to All Branches)

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	**6**
2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	**6**

3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators- SENSEX and NIFTY	6
4	Value Analysis and value Engineering - Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure - Break-even Analysis - Cost-Benefit Analysis - Capital Budgeting - Process planning	6

Course Assessment Method

(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
0	15	12.5	12.5	50

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
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks **(6x3 =18marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. **(4x8 = 32 marks)**	50

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting 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	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S3/S4

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	UCHUT347	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics -** Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places**-accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies -** sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in connection with gender** - equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	6

2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	**6**

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

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12
3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**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	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Pvt Ltd, Delhi	4" edition, 2014

Suggested Activities/Projects:
Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER: S3

COMPUTER AIDED MACHINE DRAWING & MODELLING

Course Code	**PCMEL307**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Lab

Course Objectives:

1. To introduce modern CAD packages for drafting and modelling of engineering components.
2. To create a digital mock up of engineering components

Expt. No.	Experiments
Part A	Understand the basics of machine drawing, including BIS code of practice, types of lines, dimensioning, scales of drawing, sectional views, geometric tolerances, and the importance of GD&T. Additionally, to practice, simple 2D sketches to familiarize with these concepts. Learn and practice drawing different types of rigid shaft couplings used for connecting shafts with collinear axes using 2D drafting software (Flange Coupling, Protected Flange Coupling etc). Understanding Basics of Assembly Drawings using 2D drafting software and creating a 2D Assembled Drawing with required Sectional Views (Universal coupling or Knuckle joint). Understanding Basics of Assembly Drawings using 2D drafting software and creating a 2D Assembled Drawing with required Sectional Views and prepare BOM (Stuffing Box). Use of geometrical dimensioning and tolerancing (GD & T) in drawing. (Minimum 5 Nos.)
Part B	Creating 3D machine components (Minimum 4 Nos). Creating 3D assembly models of Socket and spigot joint, Knuckle Joint, Rigid flange couplings, Bushed Pin flexible coupling, Plummer block, Screw jack etc. Modeling of surfaces of the given geometry like helmet, mouse, fender of automobiles etc. Parametric modeling of standard parts such as nuts, bolts, rivets, washers etc (Minimum 3 Nos).
Out of 12 exercises, 5 should be from Part A and 7 should be from Part B	

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the knowledge of engineering drawings to interpret 2D drawings and model them using software**.**	K3
CO2	Prepare standard assembly models and drawings of machine components using part drawings	K1
CO3	Practice GD & T in models as well as drawings	K2
CO4	Apply parameterisation for the quick modeling of standard parts	K3
CO5	Model external surfaces of common objects	K3

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

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

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

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Geometric Dimensioning and Tolerancing	James D. Medows	James D. Meadows & Associates, Inc.	
2	Fundamentals of Geometric Dimensioning and Tolerancing	Alex Krulikowski	Delmar Cengage Learning	
3	CAD, 3D Modeling, Engineering Analysis, and Prototype Experimentation	Jeremy Zhang Li	Springer	2010 5th Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Engineering Graphics and Design - Course (nptel.ac.in)

Continuous Assessment (25 Marks)

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

4. Viva Voce (10 Marks)

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

5. Record (5 Marks)

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

SEMESTER S3

MATERIALS TESTING LAB

Course Code	PCMEL308	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Lab

Course Objectives:

1. Characterize the mechanical behaviour of materials under various loading conditions.
2. Relate material properties and microstructure to engineering applications.

Expt. No.	Experiments
1	Evaluate the tensile properties of a ductile material (mild steel, high-strength steel, or tor-steel) using a Universal Testing Machine (UTM) equipped with an extensometer.
2	Conduct compressions test on a ductile material (mild steel, tor-steel, or high-strength steel) using a Universal Testing Machine (UTM) equipped with an extensometer.
3	Determine the tensile properties of cast iron (a brittle material) using a Universal Testing Machine (UTM) equipped with an extensometer.
4	Determine the shear strength of a mild steel rod using a shear test.
5	Perform Brinell/Vickers/Rockwell hardness tests on a given material
6	Determine the torsional rigidity of mild steel/copper/brass rods.
7	Evaluate the flexural stiffness (flexural rigidity) of mild steel/copper/brass specimens using a three-point bend test on a Universal Testing Machine (UTM)
8	Determine the notch toughness of the material at room temperature using Izod and Charpy impact testing.
9	Investigate the effect of coil type (close-coiled vs. open-coiled) and arrangement (series vs. parallel) on spring stiffness.
10	Microstructure of mild steel/copper/ brass/aluminium using opticalmicroscope, double disc polishing machine, emery papers and etchant.
11	Analyse the fracture surface morphology of a ductile or brittle material using an optical microscope for fractographic characterisation.
12	Evaluate the fracture toughness of a material with a Universal Testing Machine (UTM)
13	To study the procedure for plotting S-N curve using Fatigue testing machine

14	Perform stress analysis using photoelasticity.
15	Measure the deformation (strain) of an object using strain gauges.
16	Perform a bending test on a wooden beam to assess its load-carrying capacity.

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Evaluate the mechanical properties of different materials under various loading conditions.	K3
CO2	Relate material microstructure to its mechanical behaviour.	K4
CO3	Analyse the effect of design features on the performance of mechanical components.	K4
CO4	Utilize experimental techniques to determine material properties.	K3
CO5	Apply fundamental engineering principles to analyse the behaviour of structures under load.	K3

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

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

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

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

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Callister's Materials Science and Engineering	D. Wayne Callister and David G. Rethwisch	Wiley	10th Ed (2018)
2	Mechanical Testing and Evaluation	Howard Kuhn; Dana Medlin	ASM International	Volume 8 (2000)

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Mechanics of Materials	James M. Gere and Barry J. Goodno	Cengage Learning	9th Ed (2022)
2	Introduction to Materials Science for Engineers	James F. Shackelford	Pearson	8th Ed (2022)

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
1	https://onlinecourses.nptel.ac.in/noc23_mm38/preview
2	https://archive.nptel.ac.in/courses/112/107/112107146/
3	https://archive.nptel.ac.in/courses/112/106/112106293/

Continuous Assessment (25 Marks)

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

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

4. **Viva Voce (10 Marks)**

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

5. **Record (5 Marks)**

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

SEMESTER 4

MECHANICAL ENGINEERING

SEMESTER S4

MATHEMATICS FOR PHYSICAL SCIENCE – 4

(C Group)

Course Code	**GCMAT401**	**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 calculus.	**Course Type**	Theory

Course Objectives:

1. To familiarize students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science.
2. To provide the students with the basics of various numerical methods to develop problem solving skills used in various engineering disciplines.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Random variables, Discrete random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Binomial distribution, Poisson distribution, Poisson distribution as a limit of the binomial distribution, Joint pmf of two discrete random variables, Marginal pmf, Independent random variables, Expected value of a function of two discrete variables. **[Text 1: Relevant topics from sections 3.1 to 3.4, 3.6, 5.1, 5.2]**	**9**
2	Continuous random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Uniform, Normal and Exponential distributions, Joint pdf of two Continuous random variables, Marginal pdf, Independent random variables, Expectation value of a function of two continuous variables. **[Text 1: Relevant topics from sections 3.1, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2]**	**9**

3	Confidence Intervals, Confidence Level, Confidence Intervals and One-side confidence intervals for a Population Mean for large and small samples (normal distribution and *t*-distribution), Hypotheses and Test Procedures, Type I and Type II error, *z* Tests for Hypotheses about a Population Mean (for large sample), *t* Test for Hypotheses about a Population Mean (for small sample), Tests concerning a population proportion for large and small samples. **[Text 1: Relevant topics from 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4]**	**9**
4	Newton-Raphson Method, Gauss Elimination Method, Gauss - Jordan Method, Numerical solution of ordinary differential equations-Euler's method, Modified Euler's method, Runge - Kutta method of 2^{nd} Order, Numerical solution of Laplace equation –Jacobi's Method, Curve Fitting by Method of Least Squares - Straight lines, Parabola. **(Text 2: Relevant topics from sections 2.5, 4.2, 7.5, 8.4, 8.5, 9.4)**	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the concept, properties and important models of discrete random variables and to apply in suitable random phenomena.	**K3**
CO2	Understand the concept, properties and important models of continuous random variables and to apply in suitable random phenomena.	**K3**
CO3	Estimate population parameters, assess their certainty with confidence intervals, and test hypotheses about population means and proportions using *z*-tests and the one-sample *t*-test.	**K3**
CO4	Apply numerical methods to find solutions of linear system of equations, ordinary differential equations and Laplace equations.	**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	2	-	-	-	-	-	-	-	2
CO2	3	3	2	2	-	-	-	-	-	-	-	2
CO3	3	3	2	2	-	-	-	-	-	-	-	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability and Statistics for Engineering and the Sciences	Devore J. L	Cengage Learning	9th edition, 2016
2	Introductory Methods of Numerical Analysis	S S Sastry	PHI Learning Pvt Limited	5th edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability, Random Variables and Stochastic Processes,	Papoulis, A. & Pillai, S.U.,	McGraw Hill.	4th edition, 2002
2	Introduction to Probability and Statistics for Engineers and Scientists	Ross, S. M.	Academic Press	6th edition, 2020
3	Numerical methods for Engineers	Steven C. Chapra, Raymond P. Canale	McGraw Hill Education	8th edition, 2021

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/117/105/117105085/
2	https://archive.nptel.ac.in/courses/117/105/117105085/
3	https://archive.nptel.ac.in/courses/117/105/117105085/
4	https://archive.nptel.ac.in/courses/111/107/111107105/

SEMESTER S4

MACHINE TOOLS AND METROLOGY

Course Code	PCMET402	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-1-0-0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To develop knowledge of appropriate process parameters to be used for various machining operations.
2. Understand the principles and operation of precision measurement tools and equipment used in modern manufacturing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, mechanics of chip formation: orthogonal and oblique cutting, shear angle, velocity relationship; merchant's analysis of cutting forces; cutting power estimation, tool life, and wear; economics of machining, numerical problems Lathe- Types, parts, specifications of lathe, lathe operations, accessories, process parameters, machining time calculations. Shaping, Planning, and Slotting machines – Classification, types of operations.	11
2	Drilling Machines –Operations, drill bit nomenclature, process parameters, machining time calculations and cutting forces. Milling machines – types, milling operations, types of milling cutters, milling cutter nomenclature, process parameters, machining time calculations and cutting forces. Indexing head and different indexing methods. Grinding- types of grinding machines, operations, cutting forces in grinding, grinding mechanisms, grinding wheels, honing, and lapping Broaching – different machines, cutter for broaching, internal and external broaching – applications. Gear generation -Gear hobbing. Work holding - jigs, and fixtures- functions and comparison	11

3	Metrology –Need for inspection, accuracy and precision, calibration, errors in measurement, standards of measurement. Limits, fits and tolerances-Principle of interchangeability, selective assembly approach, Tolerances-Classification of Tolerance, Types of fit, Allowances-Hole basis and Shaft basis systems, System of limits and fits, numerical problems. Limit gauging-classification of gauges, Taylor's Principle, gauge tolerance – wear allowance.	**11**
4	Angular measurements-Autocollimator, Angle Dekkor. Comparators-Classification, Dial indicators, Electrical and electronic comparators, pneumatic comparators Interferometry- Principle of Interference, Optical Flats, NPL Flatness Interferometer, Pitter–NPL Gauge Interferometer and Laser Interferometers Gear measurement- Gear tooth terminology, errors in spur gears, measurement of gear elements. Screw Thread Measurement- Terminology, Measurement of major, minor, and effective diameters (2-wire and 3-wiremethods). Surface Roughness Measurement- Components of surface texture, Analysis of surface traces, Specification of surface texture, Measurement of surface roughness-Stylus probe instruments Geometric Form Measurement: Straightness, Flatness, Roundness, Concepts of coordinate-measuring machine (CMM)	**11**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe various machine tool operations	**K2**
CO2	Determine machining time and power consumption in various machining processes	**K3**
CO3	Explain limits, fits and tolerances	**K2**
CO4	Identify the uses of various advanced measuring instruments	**K1**

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

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

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2										
CO2	3	3										
CO3	3	2										
CO4	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	Elements of Workshop Technology Vol-II Machine Tools	S K Hajra Choudhury Nirjhar Roy	Media Promoters and Publishers Pvt Limited	
2	Manufacturing Science	Amitabha Ghosh Asok Kumar Mallik	Affiliated East-West Private Limited	2nd Edition 2010
3	Engineering Metrology and Measurements	N.V. Raghavendra, l. Krishnamurthy	Oxford University Press	
4	Manufacturing Engineering and Technology	Serope Kalpakjian Steven R Schmid	Pearson	Edition 5

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Workshop Technology,	Chapman W. A. J.,	Viva books (P) Ltd	
2	Metrology for Engineers,	Galyer J.F.W., Schotbolt C.R.,	ELBS.	
3	Machine Tools	Chernov	MIR Publication	
4	HMT, Production Technology		Tata McGraw-Hill	
5	Practical Engineering Metrology	Sharp K.W.B	Sir Isaac Pitman & Sons Ltd.	
6	Machine Tool Design Vol. 1 to 4	Acharkan. N	MIR Publication	
7	ASME, Hand book of Industrial Metrology.			
8	Engineering Metrology	Hume K. J	Macdonald &Co. Ltd.	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/105/112105233/
2	https://archive.nptel.ac.in/courses/112/105/112105233/
3	https://nptel.ac.in/courses/112106179
4	https://nptel.ac.in/courses/112106179

SEMESTER S4

ENGINEERING THERMODYNAMICS

Course Code	**PCMET403**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Introduce the principles and laws of thermodynamics
2. Apply laws of thermodynamics to engineering systems
3. Identify systems where laws of thermodynamics are applicable

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction and basic concepts, application areas of thermodynamics, macroscopic and microscopic viewpoints, continuum, systems and control volumes, types of systems, properties of a system, state and equilibrium, the state postulate, processes and cycles Temperature and the Zeroth law of thermodynamics, temperature scales, forms of energy, physical insight to internal energy, energy transfer by heat and work, path function.	**11**
2	First law of thermodynamics, energy balance, (energy and exercise, dieting, mass gain and mass loss, etc. Can be discussed as examples), mechanisms of energy transfer, moving boundary work, boundary work for polytropic process, energy balance for closed systems, enthalpy and specific heats, flow work and the energy of a flowing fluid, mass and energy analysis of control volumes, SFEE, steady-flow devices: nozzles and diffusers, throttling valves, mixing chambers Thermal energy reservoirs, heat engines and thermal efficiency, refrigerators and heat pumps, COP, heat pumps	**11**

3	Second law: Kelvin–Planck statement, Second law: Clausius statement, equivalence of the two statements, perpetual-motion machines, reversible and irreversible processes, internally reversible processes Carnot and Reversed Carnot cycle, Carnot principles, thermodynamic temperature scale, entropy, internally reversible isothermal heat transfer, the increase of entropy principle, the Tds relations, isentropic efficiency, exergy, reversible work and irreversibility, second-law efficiency	**11**
4	Entropy generation, S_{gen} associated with a heat transfer process, entropy generation in daily life, isentropic process, Third law of thermodynamics Phase transformations of pure substance, saturated liquid, saturated vapor and superheated vapor, triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, Mollier charts, dryness fraction, property calculations using steam tables, isentropic efficiency of steam turbines and nozzles, ideal gas equation, gas constants, deviations from ideal gas model, compressibility, Van-der-Waals equation of state	**11**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand basic concepts of thermodynamics	**K1, K2**
CO2	Understand the laws of thermodynamics	**K1, K2**
CO3	Conduct first law analysis of open and closed systems	**K3**
CO4	Determine entropy changes associated with different processes	**K3**
CO5	Determine the properties of pure substances	**K2, K3**

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

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

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

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Thermodynamics: an engineering approach.	Cengel, Yunus A., Michael A. Boles, and Mehmet Kanoğlu.	McGraw-hill	2011
2	Engineering Thermodynamics	P.K. Nag	McGraw-Hill Education	6th Edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Engineering Thermodynamics,	Moran J. Shapiro N. M.	Wiley	2006
2	Fundamentals of Thermodynamics	Richard E. Sonntag, Claus Borgnakke, Gordon J. VanWylen	Wiley	8th Edition, 2014
3	Thermodynamics: Principles and Applications	Jean-Philippe Ansermet, Sylvain D. Brechet	Cambridge University Press	1st Edition, 2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	1. Engineering Thermodynamics Prof. Suman Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/112/105/112105123/ 2. Chemical Engineering Thermodynamics Prof. Dr. Sandip Roy IIT Bombay https://nptel.ac.in/courses/103/101/103101004/
2	1. Engineering Thermodynamics Prof. Suman Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/112/105/112105123/ 2. Chemical Engineering Thermodynamics Prof. Dr. Sandip Roy IIT Bombay https://nptel.ac.in/courses/103/101/103101004/
3	1. Engineering Thermodynamics Prof. Suman Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/112/105/112105123/ 2. Chemical Engineering Thermodynamics Prof. Dr. Sandip Roy IIT Bombay https://nptel.ac.in/courses/103/101/103101004/
4	1. Engineering Thermodynamics Prof. Suman Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/112/105/112105123/

SEMESTER S4

MECHANICS OF MACHINERY

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

Course Objectives:

1. To understand the kinematics of different mechanism
2. To understand the motion resulting from a specified set of linkages and to synthesis the mechanism.
3. To understand and to design of cam mechanisms for specified output motions.
4. To understand the basic concepts of toothed gearing and kinematics of gear trains

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Concepts of Kinematics and Dynamics, Mechanisms and Machines, Planar and Spatial Mechanisms, Degrees of Freedom, Mobility analysis - Kutzbach and Grubler's criterion, Grashof's criterion. Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion, Four bar chain, Slider Crank Mechanisms, Double slider crank Mechanisms and their Inversions. Exact Straight Line Motion Mechanisms- Peaucellier mechanism, Hart's Mechanism. Approximate Straight Line Motion Mechanisms- Watt's mechanism. Steering gear mechanism- Davis steering gear, Ackermann's steering gear	9

2	Velocity analysis of mechanisms (Up to six links)– relative motion - relative velocity. Instantaneous centre -Kennedy's theorem-velocity analysis using instantaneous centre. (Up to six links) Acceleration analysis- Relative acceleration - Coriolis acceleration (Crank and slotted lever and Whitworth quick return mechanism)	**9**
3	Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis –Definitions of Motion, Path and Function generation, precision points, Chebychev spacing, Freudenstein's equation. Cams - Types of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion- Graphical cam profile synthesis- knife edge and roller follower with and without offset	**9**
4	Gears – Classification- Terminology of spur, helical bevel, and worm gear – Law of gearing -tooth profiles-path of contact- arc of contact- contact ratio - interference- minimum number of teeth to avoid interference -undercut- backlash Gear trains - simple and compound gear trains - planetary gear trains. Tabulation method	**9**

Suggestion on Project Topics

- Students should be given projects which may include development of computer codes of analytical methods, computer models and computer aided simulations, and development of functioning proto type of various mechanisms.

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Calculate degrees of freedom of mechanisms and Interpret their inversions.	**K3**
CO2	Perform velocity and acceleration analysis of various planar mechanisms	**K4**
CO3	Construct a mechanism for a specified output motion	**K4**
CO4	Solve the problem on cams and gear drives, including selection depending on requirement.	**K3**
CO5	Create prototype of various mechanisms.	**K6**

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

CO-PO Mapping Table:

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Theory of Machines and Mechanisms	Ballaney P. L.	Khanna Publishers	2005
2	Theory of Machines	S. S. Rattan	Tata McGraw Hill	2009
3	Theory of Mechanisms and Machines	A Ghosh	East West	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Kinematics and Dynamics of Machinery	C. E. Wilson, P. Sadler	Pearson Education	2005
2	Theory of Machines and Mechanisms	J. E. Shigley, J. J. Uicker	McGraw Hill	2010
3	Machines and Mechanisms Applied Kinematic Analysis	D. H. Myskza	Pearson Education	2013
4	Kinematics and Dynamics of Machinery	Norton	Tata McGraw Hill	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	www.youtube.com for mechanism animations
2	https://archive.nptel.ac.in/courses/112/105/112105268/
3	https://archive.nptel.ac.in/courses/112/105/112105268/
4	https://archive.nptel.ac.in/courses/112/105/112105268/

- *Students should be given projects which may include development of computer codes of analytical methods, computer models and computer aided simulations, and development of functioning proto type of various mechanisms.*

PBL Course Elements

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

Assessment and Evaluation for Project Activity

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

1. **Project Planning and Proposal (5 Marks)**

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

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

   - Individual contribution to the presentation

- Effectiveness in answering questions and handling feedback

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

- Active participation and individual contribution
- Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

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

5. **Final Presentation (5 Marks)**

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

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

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

SEMESTER S4

TURBO MACHINERY

Course Code	PEMET411	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Fluid Mechanics and Machinery PCMET303	Course Type	Theory

Course Objectives:

1. To understand how to apply the fundamental principles of fluid mechanics and thermodynamics in the operation of different turbomachines
2. To give an insight in the general analysis of radial flow and axial flow turbomachines.
3. To familiarize and understand the working and the performance of different power generating turbomachines
4. To familiarize and understand the working and the performance of different power consuming turbomachines

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Definition of turbo machine, Classification: Axial flow, radial flow and mixed flow machines, parts of turbo machines, Comparison with positive displacement machines. **Thermodynamics of fluid flow:** Application of first and second law of thermodynamics to turbo machines. Preheat factor in compressors, work and efficiency for compressors and turbines. **Energy exchange in Turbo machines:** Euler's equation, Alternate form of Euler's equation, components of energy transfer.	9
2	**General Analysis of Turbo machines:** **Radial flow compressors**– general analysis, degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance. **Axial flow compressors-**degree of reaction, velocity triangles.	9

3	**Hydraulic Turbines:** Classification **Pelton Wheel** – Principle of working, velocity triangles, efficiencies and losses. **Reaction turbines** – Francis turbine: Principle of working, velocity triangles, efficiencies and losses, draft tube, governing, cavitation. **Kaplan and Propeller turbines -** Principle of working, velocity triangles, efficiencies and losses.Selection turbines for power plants	9
4	**Centrifugal Pumps:** Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Theoretical head – capacity relationship, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. **Fans, Blowers and Compressors:** Classification and working principles of fans, blowers and compressors. **Centrifugal Compressors:** Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems.	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	Use the fundamental principles of fluid mechanics and thermodynamics and find the efficiencies of power generating and power consuming turbomachines.	**K3**
CO2	Analyse the velocity triangles for radial flow and axial flow turbomachines and find the performance for parametrical changes.	**K3**
CO3	Select an appropriate power generating turbomachine for a particular application	**K3**
CO4	Select an appropriate power consuming turbomachine for a particular application	**K3**

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

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	3	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	Fluid Mechanics and Thermodynamics of Turbomachinery	Dixon, S.I,	Pergamom Press	1999
2	Fundamentals of Turbo Machinery	B.K Venkanna	PHI Learning Pvt. Ltd	1st Edition 2009
3	Turbines, Compressor and Fans	Yahya, S.H,	Tata Mc Graw Hill,	1996

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Turbomachinery – Fundamentals, Selection and Preliminary Design	Marco Gambini, Michela Vellini	Springer	1st Edition, 2021
2	Fundamentals of Turbomachines	Erik Dick	Springer	2nd Edition 2022

Video Links (NPTEL, SWAYAM…)	
Module No.	Link ID
1	https://www.youtube.com/watch?v=ocVzrn 4DLj8 (types and classification) https://youtu.be/DlkmkeENGwg (Euler's equation and fundamentals)
2	https://youtu.be/DlkmkeENGwg (Radial and Axial Flow, Velocity triangles)
3	https://youtu.be/hJA7jPice Tg (Pelton Wheel) https://youtu.be/utOHXJvq I9o https://youtu.be/MtueN0By KIs (Francis Turbine) https://youtu.be/b7kTKdEISHc (Kaplan Turbine)
4	https://youtu.be/VQqiVVYuNks https://youtu.be/_-yk5GwFnKM (Centrifugal Pumps)

SEMESTER S4

NUCLEAR ENERGY

Course Code	PEMET412	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Mins.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To explore the motivations and basic physics for nuclear reactors
2. To understand the power plant and reactor fuel cycle
3. To understand the components of nuclear reactor.
4. To acquire nuclear waste management and Indian nuclear power program

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**MOTIVATION FOR NUCLEAR ENERGY SOURCE:** Role of electricity; energy disparities among countries; energy sources; present source of energy; global resource estimates; issues associated with fossil fuels, potential role of nuclear energy; current status of nuclear energy & Indian energy resources. **BASIC PHYSICS OF NUCLEAR REACTORS:** Isotopes; binding energy; nuclear stability; α, β, γ and neutron interactions; concept of neutron cross section, radioactive decay law; units of radioactivity; Fission – fission energy, critical mass, Gabon – natural reactor, liquid drop model of fission cross section, prompt & delayed neutrons, neutron life cycle, infinite multiplication factor and 4 factor formula and 6 factor formula; effective multiplication factor; neutron moderation, moderator, slowing down; criticality, reactive power; reactor kinetics & control.*(Analytical treatment excluded)*	9

2	**REACTOR FUEL CYCLE;** fuel cycle material balance, uranium mining & milling; uranium conversion to uranium hexafluoride; enrichment – gaseous: diffusion & centrifuge; fuel fabrication; commuting radioactive materials; storage of spent fuel; reprocessing – solvent extraction: purex, urex, truex, pyro processing: electrolysis.*(Analytical treatment excluded)*	**6**
3	**COMPONENTS OF NUCLEAR REACTOR:** Fermi pile – control, safety, radiation monitoring; reactor core; fuel, control rods; moderator; essential core components; containment; core catcher; steam generator; turbine generator; steam water system; turbine generator; steam water system; fuel handling; cooling spent fuel; Nuclear reactor types-pressurized water reactor, boiling water reactor, Canada-deuterium reactor, solid cooled fast reactor, advanced gas cooled reactor. **NEXT GENERATION REACTORS:** basic knowledge and conceptual difference of next generation reactors only – Generation I, II, III, IV;~~.~~ Fusion reaction- Lawson criterion, inertial and magnetic confinements (*Analytical treatment excluded)*	**12**
4	**RADIATION SAFETY ANDNUCLEAR WASTE MANAGEMENT:**; Biological effects of radiation and shielding Radioactive waste type – exempted and low-level waste; classified low, intermediate and high level waste; treatment and conditioning of nuclear waste – incineration, compaction, cementation, vitrification; Waste disposal methods – near surface disposal, deep geological disposal, disposal at outer space, deep boreholes and disposal at sea. **INDIAN POWER PROGRAM:** installing a nuclear establishment; research reactor apsara, Canada-India research reactor, Indian 3 stage nuclear program – advanced heavy water reactor, accelerator driven sub-critical systems, compact temperature reactor. *(Analytical treatment excluded*)	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describe the key components of a nuclear reactor system and their functions	**K2**
CO2	Explain the principles of reactor control and safety mechanism	**K2**
CO3	Analyse the role of fuel cycle	**K2**
CO4	Discuss importance of containment structures & mitigation strategy for potential accidents	**K2**
CO5	Evaluate different options for fuel handling and spent fuel management	**K3**
CO6	Understand the regulatory framework for nuclear reactor safety	**K2**
CO7	Critically analyse the safety aspects of historic and future reactor design	**K3**

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

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

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

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

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Engineering Physics	R K Guptha& S L Gaur	DhanpatRai Publications	45th Edition (2012)
2	Nuclear reactor engineering	Dr G Vaidyanathan	S Chand & co Pvt Ltd	1st Edition (2013)

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Nuclear Reactor Engineering	S. Glasstone and A. Sesonske,	D. Van Nostrand Company, INC.	1967
2	Source book on atomic energy	S Glasstone	D.VanNostrand Co,196	1967

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/112/101/112101007/
2	https://www.youtube.com/watch?v=1U6Nzcv9Vws
3	https://www.youtube.com/watch?v=jpDRfaWYk3I
4	https://archive.nptel.ac.in/courses/112/101/112101007/

SEMESTER S4

COMPOSITE MATERIALS

Course Code	PEMET413	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. Impart knowledge about the definition, benefits, and classification of composite materials.
2. The students will be able to understand the concept of various matrices and reinforcements used in composites.
3. The course also covers about types of fibers, polymer matrix composites, metal matrix composites, ceramic matrix composites and its manufacturing and applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Composite**: Introduction, definition, characteristics, functions, classification of composites based on structure and matrix, smart composites, industrial applications. Interfaces: wettability and bonding interface in composites. Types of bonding at interface. **Fibers** : Introduction, types of fibers, natural fibers, glass fiber fabrication, structure, properties and applications, boron fiber fabrication, structure, properties and applications.	9
2	**Polymer matrix composites (PMC):** Thermoset, thermoplastic and elastomeric polymers, properties, characteristics and applications as matrix materials. Processing of polymer matrix composites: hand layup methods and spray layup method. Moulding methods: pressure bagging and bag moulding methods, Autoclave-based processing with prepregs, pultrusion and filament winding process.	9

3	**Metal matrix composites (MMC)**: classification of metals, intermetallics, alloys and their potential role as matrices in composites, properties, characteristics and applications of metals as matrix materials, production techniques: powder metallurgy, diffusion bonding, melt stirring, squeeze casting, liquid infiltration under pressure, insitu process.	9
4	**Ceramic matrix composites (CMC):** classification of ceramics and their potential role as matrices, properties, characteristics and applications of CMC, conventional production techniques: cold pressing and sintering, hot pressing, reaction bonding, liquid infiltration, pultrusion. lanxide process, insitu chemical technique, sol-gel technique.	9

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand about composites, various matrices and reinforcements used in composites, types of fibres	**K1, K2**
CO2	To know about polymer matrix composites, classification, properties, characteristics and applications, manufacturing methods.	**K1, K2**
CO3	To know about metal matrix composites, classification, properties, characteristics and applications, manufacturing methods.	**K1, K2**
CO4	To know about ceramic matrix composites, classification, properties, characteristics and applications, manufacturing methods.	**K1, 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	-	1	-	-	3	2	2	-	-	-	1
CO2	3	-	1	-	-	3	2	1	-	-	-	2
CO3	3	-	1	-	-	3	2	2	-	-	-	1
CO4	3	-	1	-	-	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	Composite Materials : Science and Engineering	K. K. Chawla	Springer	3rdEdn 2013
2	Fiber-reinforced composites,	P.K.Mallicak	MonalDeklar Inc., New York	1988
3	Mechanics of Composite Materials; Selected Works of Nicholas J. Pagano	Reddy J N	Springer	1994
4	Mechanics of Composite Materials	Robert M. Jones	CRC Press	1998

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Composite Materials, Engineering and Sciences	F.L.Matthews&R.D.Rawlings	Chapman & hall, London	1994
2	Stress Analysis of Fiber - Reinforced Composite Materials	MicaelHyer	Tata McGraw Hill	1998

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.youtube.com/watch?v=JBMVZpRD-Zk
2	https://www.youtube.com/watch?v=tP8JCX87DzI
3	https://www.youtube.com/watch?v=RihoVfzEfWI
4	https://www.youtube.com/watch?v=LGERbwD5S2g

SEMESTER S4

COMPONENTS OF INTELLIGENT SYSTEMS

Course Code	**PEMET414**	**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. The students will have the ability to understand the working of various sensors and transducers.
2. The students will have the ability to develop systems for actuation of mechanical systems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Sensors and Transducers:** **Internal Sensors**: Position - Optical Encoders, Potentiometers, LVDT, Velocity - Encoders, Tachogenerators, Acceleration – Different types of accelerometers, Gyroscopes, IMU, Force transducers **External Sensors**: Contact Sensors, Inductive and Capacitive Proximity sensors, GPS, Ultrasonic transducers and SONAR, RADAR and Doppler effect, LIDAR **Sensor Characteristics**: Sensitivity, Linearity, Measurement /Dynamic range, Response Time, Accuracy, Repeatability and Precision, Resolution & Threshold, Bandwidth	9
2	**Actuators:** **Hydraulic and Pneumatic Actuators:** Working of Hydraulic and Pneumatic Actuators at block diagram level, advantages and disadvantages of each **Electric Actuators:** Electric motors - DC motors, Stepper motors, Servo motors, BLDC motors, Transmission Elements, advantages and disadvantages of Electric Actuators	9

3	**Microcontrollers:** Definitions of microprocessors and microcontrollers with basic block diagrams and differences between them **Arduino Uno microcontroller:** Board Study (Board level Block schematic) - Chip (Features only – Architecture not needed), GPIO, Memory, Programming Interface **Programming**: Arduino IDE, Sample Code for interfacing LED and Switch, DC motor and Stepper motor control, LCD Interfacing	9
4	**Introduction to Embedded Systems and IoT:** **Embedded Systems:** Applications of embedded systems-Consumer electronics, Robotics, Automobiles **Embedded System Architecture:** Hardware - Processor, Controller, Memory, Peripherals; Software - Application, Middleware, OS, Device Drivers, Tool chain- Assembler, Interpreter, Compiler, Linker, Loader, Debugger **IoT**: Definition, Impact of IoT in Manufacturing, Smart homes, Transportation and Cities **Wired Communication:** Basics of Serial communication (UART, SPI, I2C) **Wireless Communication:** Basics of Wi-Fi, Bluetooth, Zigbee, LoRa, and NFC **Case Study:** Design and implementation of a simple Embedded/IoT project	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 working of sensors and transducers	**K2**
CO2	Describe the operation of actuators for intelligent systems	**K2**
CO3	Develop the hardware and software for microcontroller based systems for actuation	**K3**
CO4	Outline the basic concepts of Embedded Systems and IoT	**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
CO3	3	3	3	-	3	-	-		-	-	-	3
CO4	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	Introduction to Robotics	S K Saha	McGraw-Hill Education (India)	2008
2	Sensors, Actuators, and their Interfaces: A multidisciplinary introduction	SciTech Publishing Inc	SciTech Publishing Inc	2011
3	Beginning Arduino	Michael McRoberts	Apress	1^{st} Edition, 2011
4	Embedded Systems: An Integrated Approach	Lyla B Das	Pearson Education India	1^{st} Edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Sensors and Transducers	D. Patranabis	PHI Learning	2nd edition, 2003
2	Embedded Systems Architecture, programming and Design	Raj Kamal	Tata McGraw-Hil	3^{rd} edition, 2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.swayam2.ac.in/aic20_sp04/unit?unit=4&lesson=7

SEMESTER S4

ADVANCED METAL JOINING TECHNIQUES

Course Code	**PEMET416**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	4/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To establish fundamental knowledge Advanced welding technologies
2. To enable the learner to select appropriate metal joining technique based on the application.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Solid State Welding**: Principle and mechanism of solid-state welding, techniques, process parameters and applications of diffusion welding, cold pressure welding. **Adhesive Bonding**: Principle – types of adhesives, bonding methods – applications.	9
2	**Explosive welding:** principle and theory, equipment used, Process parameters and characteristics, weld joint design, Applications, advantages, and limitations. **Friction and Friction stir welding:** principle and theory – Process parameters and applications, Tools, and Metal flow. **Ultrasonic Welding:** principle, theory, and types – Welding environment, equipment used- Process parameters and characteristics, weld joint design and applications.	9

3	**Electron Beam Welding (EBW)** - principle and theory, Welding environment, equipment used- Process parameters and characteristics, weld joint design, Applications, advantages, and limitations. **Laser Beam Welding (LBW)** – Principle and theory, types of lasers, Process parameters and characteristics, Applications, advantages, and limitations. **Plasma Arc Welding (PAW) –**Theory – transferred arc and non-transferred arc techniques, equipment – applications.	**9**
4	**Magnetically Impelled Arc Butt (MIAB)**– principle and applications. Under water welding – wet land dry under water welding- set-up for underwater welding systems. **Brazing** – Principle – processes involved – torch brazing, furnace brazing, vacuum brazing, induction brazing – advantages and applications. **Micro-joining and nano-joining:** Introduction, theory, and applications.	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Summarise the Solid-state welding techniques and outline the physics of adhesive bonding.	**K2**
CO2	Compare and select between explosive welding, friction welding and ultrasonic welding based on the applications.	**K3**
CO3	Understand radiant energy welding technologies and explain the principle and working of EBW, LBW and PAW.	**K2**
CO4	Outline the modern joining technologies and select appropriate brazing technique to resolve modern metal joining problem.	**K3**

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

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

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

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Advanced welding Processes	J. Norrish	Woodhead publishing	2006
2	Welding Processes and Technology	Parmar R. S	Khanna Publishers	1998

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Welding	R. W. Messler	John Wiley and Sons	1999
2	Metal Joining Manual	Schwartz M. M	McGraw-Hill Inc.	1979
3	Micro-joining and Nano-joining	Y. N. Zhou	Woodhead publishing	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/112103244
2	https://nptel.ac.in/courses/112103244
3	https://nptel.ac.in/courses/112103244
4	https://nptel.ac.in/courses/112103244

SEMESTER S4

TECHNOLOGY MANAGEMENT

Course Code	PEMET417	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. Develop a holistic understanding of management theory, covering management functions, system approaches, managerial tasks, the management process, and various domains including operations, human resources, marketing, corporate social responsibilities, finance, entrepreneurship, and intellectual property rights.
2. Explore the evolution of technology over the past two centuries, its impact on human needs, dimensions of technology management, and its role in business plans, competition, innovation, and research, with a focus on the Indian context and key aspects such as change, life cycle, diffusion, growth, transformation, and socio-economic planning.
3. Examine the implications of technological changes on production functions, innovation dynamics, service sectors, and macro-economic effects, focusing on technology absorption, terminology, government initiatives, and future strategies, with a specific emphasis on the Indian context.
4. Analyse the multifaceted impacts of technological changes, including production function dynamics, innovation paradigms, service sector evolution, and technology absorption processes, with a special focus on the Indian context and government initiatives for managing technological advancements

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Management theory: management definition & functions; system approaches to management; task & responsibilities of manager; management process; planning; organizing; decision making; management: operations; human resource; marketing; corporate & social responsibilities, financial; entrepreneurship; patent & Intellectual property rights.	9
2	Technology concept: significant technology changes during last 2 centuries; direct and indirect effect of technology on human need factors; dimensions of technology management; role & importance of technology management; business plan; technology & competition; new ventures; innovation; research; research infra structure; examples of speed of introducing technology development into social use; technology management in Indian context, Aspects and issues of technology management: technology – change, life cycle, diffusion & growth, transformation, alternatives, appropriateness, policy instruments, planning, development options & strategies	9
3	Implication in technology changes: production function and technology change, Nature of technology change – innovation: incremental, radical; new technology system: technology revolution: information technology revolution, Changes in service; personal service, process changes, macro-effects of technological change; knowledge intensity' skill mismatch; erosion of competitive mismatch in developing countries. Technology absorption: technology – package & dependence, terminology and concepts in absorption, Technology import in India & Indian experience, managing technology absorption, government initiatives.	9
4	Technology environment: Science & Technology in India; policies, linkages at enterprise levels, Technology support systems: financing; information systems; organizing technology at enterprise level, Technology forecasting: innovation chain; necessity; role; classification forecasting approaches; methods; methodology comparison; pitfalls & mistakes. Digital Transformation and Industry 4.0: Concepts and significance of digital transformation. Industry 4.0 technologies: IoT, AI, ML, Big Data, Robotics, and Cyber-Physical Systems. Impact of digital transformation on business models and processes.	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	Demonstrate a comprehensive understanding of management theories, including definitions, functions, and system approaches, to effectively fulfil managerial tasks and responsibilities.	**K1**
CO2	Analyse and apply various management processes such as planning, organizing, and decision-making across diverse domains including operations, human resources, marketing, and corporate social responsibilities.	**K2**
CO3	Evaluate the role and significance of entrepreneurship, financial management, and intellectual property rights within the broader context of management theory.	**K5**
CO4	Critically assess significant technological changes over the past two centuries and their direct and indirect effects on human needs, while exploring dimensions of technology management and its importance in business planning and competition.	**K5**
CO5	Synthesize the implications of technological changes, including production function dynamics, innovation paradigms, and the macro-effects of technology on service sectors and competitive landscapes, with a focus on technology absorption, policy instruments, and future strategies.	**K5**

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

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

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

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Management of Technology and Innovation: Competing Through Technological Excellence	P N Rastogi	SAGE Publications,	2009
2	Managing Strategic Innovation & Change	Tushman, M.L. and Anderson	Oxford University Press, New York,	2004
3	Management of Technology and Innovation,	Khurana, V. K.	Ane Books New Delhi,	2012
4	Managing Technology and Innovation for Competitive Advantage	Narayanan	Pearson Education,	2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	RobertA, Burgelman, Clayton.M.Christensen, Steven.C.Wheelright,	Strategic Management of Technology and Innovation	McGraw-Hill Education	5^{th}, 2009
2	Paul Trott,	Innovation Management and New Product Development	Pearson Education,	2009
3	Afuah, A	Innovation Management, Strategies, Implementation and Profits	Oxford University Press,2009	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/106/110106157/
2	https://archive.nptel.ac.in/courses/110/106/110106157/
3	https://archive.nptel.ac.in/courses/110/106/110106157/
4	https://archive.nptel.ac.in/courses/110/106/110106157/

SEMESTER S4

SUPPLY CHAIN AND LOGISTICS MANAGEMENT

Course Code	**PEMET418**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. Understand the complexity and key issues in supply chain management.
2. Describe logistics networks, distribution planning, routing design and scheduling models.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Understanding the Supply chain, Achieving strategic fit in a supply chain. Supply chain drivers and metrics. Analysing and designing the supply chain network, factors affecting distribution network design, role of network design, models for designing regional network configuration. Impact of globalisation on supply chain networks.	**9**
2	Demand forecasting in supply chain, role of forecasting, components of forecasting, forecasting methods. Aggregate planning in supply chain, basic trade-offs in aggregate planning, linear programming in aggregate planning. Coordination in supply chain, impact of lack of coordination in the chain, obstacles to coordination, managerial levers to improve coordination.	**9**
3	Managing economies of scale in a supply chain: Cycle inventory, Aggregating Multiple Products in a Single Order & Quantity Discounts. Managing uncertainty in a Supply chain – Safety inventory: Factors affecting the optimal level of product availability. Impact of supply uncertainty on safety inventory. Impact of aggregation on safety inventory. Factors affecting the optimal level of Product availability.	**9**

4	Logistics management and its components. Modes of transportation and their performance Characteristics & Transportation infrastructure policies. Design options for a transportation and logistics network. Trade-offs in transportation design, Tailored transportation. Role of sustainability in a supply chain. Sustainability connected supply chain drivers.	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 analyse supply chains and design the supply chain network.	K4
CO2	To solve demand forecasting problems in the supply chain and enhance coordination in the network.	K4
CO3	To plan and manage inventories in the supply chain.	K4
CO4	To develop and plan transportation networks for supply chain considering sustainability also.	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	2	1	2								
CO2	2	2		2						2		
CO3	2	2		2								
CO4	2	2	1	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	SupplyChain Management:Strategy, planning & Operation	Sunil Chopra and Dharam Vir Kalra	Pearson	7th edition, 2019

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Designing and managing the supply chain concepts, strategies, and cases studies	David Simchi- Levi, Edith Simchi-Levi	McGraw Hill	4th edition, 2022

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/110106045
2	https://nptel.ac.in/courses/110106045
3	https://nptel.ac.in/courses/110106045
4	https://nptel.ac.in/courses/110106045

SEMESTER S4

ADVANCED MECHANICS OF SOLIDS

Course Code	**PEMET415**	**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)	PCMET302 Mechanics of Solids	**Course Type**	Theory

Course Objectives:

1. To study the methodologies in theory of elasticity at a basic level.
2. To acquaint with the solution of advanced bending problems.
3. To study the methods for torsion in components with non-circular cross section and thin-walled structures.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to theory of elasticity – 3D stress components in rectangular and cylindrical coordinate systems– strain-displacement relations (no derivation required) - constitutive equations (no derivation required)-stress transformation– octahedral shear stress-equations of equilibrium. Boundary value problems: Different boundary conditions-Examples for Displacement Formulation/ Force Formulation.	9
2	Equations in polar coordinates (2D) – equilibrium equations, strain displacement relations - Airy's stress function and equation – polynomial method of solution – solution for bending of a cantilever beam with end load Application of stress function to Lame's problem and stress concentration problem of a small hole in a large plate (only Stress distribution)	9
3	Axisymmetric problems: thin cylinders pressurized from inside, and thick cylinders-pressurized from inside and outside - Rotating disks. Unsymmetrical bending of straight beams possessing two axes of symmetry-shear centre-Winkler Bach theory for Bending of curved beams (with rectangular cross-section).	9

4	Torsion of non-circular bars: St.Venant's and Prandtl's methods-solutions for elliptical cross-section. Membrane analogy. Torsion of thin-walled tubes, thin rectangular sections, rolled sections and multiply connected sections	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 field equations of Elasticity.	**K1**
CO2	Model engineering problems as two-dimensional, for solutions involving a Stress Function.	**K2**
CO3	Develop solutions for axi-symmetric problems for applications in thick pressure Vessels and in rotating circular discs.	**K6**
CO4	Extend the basic ideas related to theory of elastic flexure, for skewed loading and for beams which are curved.	**K4**
CO5	Apply solution methods for torsion in components with non-circular cross Sections and thin-walled structures.	**K3**

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

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

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

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Theory of Elasticity	S.P.Timoshenko and J.N. Goodier	McGrawHillEducation	ThirdEdition,2009
2	Advanced Mechanicsof Solids	LSSrinath	Tata McGraw Hill Publishing Company,	ThirdEdition,2008
3	Solid Mechanics	S.M.A. Kazimi	McGrawHill	2008
4	Advanced Mechanics of Materials	S. Jose	Pentagon Educational Services	2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	AdvancedStrength of Materials	J.P.Den Hartog	McGrawHill	1987
2	Engineering Solid Mechanics,Fundamentals and Applications	RagabA.R.and Bayoumi S. E.	CRCPress	FirstEdition.2018
3	Elasticity:Theory, Applications and Numerics	SaddM. H.	AcademicPress	SecondEdition,2012
4	An introduction the theory of elasticity	R.J.Atkin,andN.Fox	Longman	1980

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/101/112101095/
2	https://archive.nptel.ac.in/courses/112/101/112101095/
3	https://archive.nptel.ac.in/courses/112/101/112101095/
4	https://archive.nptel.ac.in/courses/112/101/112101095/

SEMESTER S4

ECONOMICS FOR ENGINEERS

(Common to All Branches)

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	6
2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	6

3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators-SENSEX and NIFTY	**6**
4	Value Analysis and value Engineering - Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure - Break-even Analysis - Cost-Benefit Analysis - Capital Budgeting - Process planning	**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
10	**15**	**12.5**	**12.5**	**50**

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
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks **(6x3 =18marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. **(4x8 = 32 marks)**	**50**

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting 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	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S3/S4

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics** - Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places-**accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies** - sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in connection with gender** - equity, diversity & gender justice, **Gender policy**	**6**

	and women/transgender empowerment initiatives.	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	6
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	6
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-	6

	world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

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

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12
3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**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	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:

Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).

- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S4

FLUID MECHANICS AND HYDRAULIC MACHINES LAB

Course Code	**PCMEL407**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0-0-3-0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Fluid Mechanics and Machinery (PCMET303)	**Course Type**	Lab

Course Objectives:

1. To familiarize the applications of fluid mechanics and dynamics.
2. To get acquainted with the practical implication of viscous flow and discharge measuring equipment in both closed & open channel flow.
3. To gain practical experience in handling various hydraulic machines.

Expt. No.	Experiments
1	Determination of coefficient of discharge and calibration of Notches.
2	Determination of coefficient of discharge and calibration of Orifice meter.
3	Determination of coefficient of discharge and calibration of Venturi meter.
4	Determination of hydraulic coefficients of orifices and mouthpieces with constant and varying head.
5	Determination of Chezy's constant and Darcy's coefficient on pipe friction apparatus.
6	Determination of the minor losses in pipe.
7	Experiments on hydraulic ram.
8	Reynolds experiment.
9	Bernoulli's experiment.
10	Determination of metacentric height and radius of gyration of floating bodies.
11	Performance test on Positive displacement pumps.
12	Performance test on Centrifugal pumps and determination of operating characteristics.
13	Performance test on Gear pump.
14	Performance test on Pelton turbine and determination of operating characteristics.

15	Performance test on reaction turbines (Francis and Kaplan Turbines) and determination of operating characteristics.
16	Speed variation test on Pelton turbine.

- Minimum 10 experiments should be completed

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the fundamental principles of fluid mechanics to understand the flow of fluid through pipes, notches, and associated losses.	**K3**
CO2	Select a pump/turbine based on the given operating conditions and determine the performance of a given Turbo machine under various operating conditions.	**K4**
CO3	Demonstrate the ability to work in groups and present results. Also, understand the ethical issues with decision making and professional conduct.	**K5**

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

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

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

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

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fluid Mechanics	Cengel Y. A. and J. M. Cimbala	Tata McGraw Hill	2013
2	Introduction to fluid mechanics and fluid machines	Som S.K	McGraw Hill Education	2011
3	Fluid mechanics and hydraulic machines	Bansal R. K	Laxmi Publications	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fluid Mechanics	White F.M.	Tata McGraw Hill	2003
2	Engineering applications of fluid dynamics	Fisher & Henley	Willford Press	2023

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Fluid Statics – https://www.youtube.com/watch?v=rY7bvZn75Do&list=PLwdnzlV3ogoWrAmpEcsPXayfsXnFfYY1O&index=4 Bouyancy, Metacentre and stability https://www.youtube.com/watch?v=gMuucNxc7eI&list=PLwdnzlV3ogoV-ATGY2ptuLS9mwLFOJoDw&index=7&pp=iAQB
2	Fluid kinematics – https://www.youtube.com/watch?v=rY7bvZn75Do&list=PLwdnzlV3ogoWrAmpEcsPXayfsXnFfYY1O&index=4
3	Internal viscous flow – https://www.youtube.com/watch?v=qLx7ip0eBps&list=PLCoE5wxWtHFYiVGswvsWRaHjv18vxZzE2&index=17
4	Introduction to turbomachines – https://www.youtube.com/watch?v=ocVzrn4DLj8&list=PLbMVogVj5nJQQp3QLuzbcHrt0XncZZTiE&index=2

Continuous Assessment (25 Marks)

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

   - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
   - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.

- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

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

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

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

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

4. Viva Voce (10 Marks)

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

5. Record (5 Marks)

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

SEMESTER: S4

MANUFACTURING TECHNOLOGY LAB

Course Code	**PCMEL408**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Lab

Course Objectives:

1. To understand the parts of various machine tools and impart hands-on experience on lathe, drilling, shaping, milling, grinding, tool and cutter grinding machines.
2. To study process parameters and practice arc and gas welding technologies.

Expt. No.	Experiments
1	Exercises on lathe: - Plain and step turning.
2	Exercises on lathe: - Ball & curve, and Taper turning.
3	Exercises on lathe: - Thread cutting.
4	Exercises on lathe: - Measurement of cutting forces in turning Process.
5	Exercises on shaping machine: - flat surfaces.
6	Exercises on shaping machine: - Grooves and key ways.
7	Exercises on drilling machine: - drilling, boring, reaming, taping and counter sinking etc.
8	Exercises on drilling machine: - Measurement of cutting forces in drilling process.
9	Exercises on cylindrical grinding machine: - Grinding of a plain cylindrical surface.
10	Exercises on surface grinding machine: - Grinding of a flat surface.
11	Exercises on tool and cutter grinding machine: - Grinding of a single-point cutting tool.
12	Exercises on milling machine: - Plane and pocket milling operations.
13	Exercises on milling machine: - Spur gear cutting operation.
14	Exercises on milling machine: - Measurement of cutting forces in milling process.
15	Exercises on arc welding: - butt welding and lap welding of M.S. sheets.
16	Exercises on gas welding: - butt welding and lap welding of M.S. sheets.
17	Study and preparation of program, simulation and exercise on CNC lathe:-turning, step turning, taper turning, thread cutting, ball and cup turning etc.

18	Study and preparation of program, simulation and exercise on CNC milling machine: - surface milling, pocket milling, contour milling etc.
19	Metallurgy: - Specimen preparation, etching & microscopic study of Steel, Cast iron and Brass and grain size measurement.
20	Exercises on part quality inspection using machine vision systems.
21	Exercises on industrial robots- manual and programmed path planning

A minimum of 12 sets of experiments are mandatory but both experiments mentioned for programming and experiments on CNC machines are mandatory.

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	The students can operate different machine tools with understanding of work holders and operating principles to produce different part features to the desired quality.	**K3**
CO2	Apply cutting mechanics to metal machining based on cutting force and power consumption.	**K3**
CO3	Programming and manufacturing of complex profiles in CNC machines with high precision.	**K3**
CO4	Fabricate and assemble various metal components by welding and students will be able to visually examine their work and that of others for discontinuities and defects.	**K3**
CO5	Gain knowledge on the structure, properties, testing and applications of ferrous and non ferrous metals.	**K3**

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

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

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

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	Production Technology	HMT	Tata McGraw Hill	2017
2	Workshop Technology Part I	W. A. J. Chapman	ELBS & Edward Arnold Publishers	1972
3	Numerical Control of Machine Tools	Yoram Koren	McGraw-Hill	2014
4	Production Technology	HMT	Tata McGraw Hill	2017

Continuous Assessment (25 Marks)

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

4. **Viva Voce (10 Marks)**

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

5. **Record (5 Marks)**

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

SEMESTER 5

MECHANICAL ENGINEERING

SEMESTER S5

DYNAMICS OF MACHINERY

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

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

SEMESTER 5

ADVANCED MANUFACTURING ENGINEERING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

Text Books

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

Reference Books

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/112105211
2	https://nptel.ac.in/courses/112104028
3	https://nptel.ac.in/courses/102108078
4	https://nptel.ac.in/courses/112103306

SEMESTER S5

HEAT AND MASS TRANSFER

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

Course Objectives:

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

SYLLABUS

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

	gradient. Heat transfer through extended surfaces – classification of fins – heat 1transfer rate from a fin (rectangular fin, pin fin) – boundary conditions – fin effectiveness and fin efficiency. Introduction to finite difference method for steady state heat conduction analysis.	
2	**Convection heat transfer** Forced convection – concept of thermal and hydrodynamic boundary layers (internal and external flows) –thermal diffusivity – momentum diffusivity – fluid friction and heat transfer relationship – developing and developed flows (hydrodynamic and thermal). Non dimensional number in heat transfer. External heat convection from flat plate/cylinder/ sphere during laminar and turbulent flow. Internal heat transfer in a circular pipe during laminar and turbulent flow. Analogy between heat and momentum transfer. Natural convection – natural convection heat transfer from vertical plate, horizontal and vertical cylinder. Heat exchanger – classification – design considerations and parameters – compact heat exchangers – effect of fouling- heat exchanger analysis – LMTD and NTU methods. Introduction to heat pipes.	**10**
3	**Radiation heat transfer** Basic laws of radiation heat transfer – Black, gray, diffuse and real surfaces - emission characteristics and laws of black body radiation - solid angle and radiation intensity – radiation heat exchange between two infinite and finite back surfaces – shape factors- radiation heat exchange between two infinite parallel diffuse gray surfaces. Electrical network analogy for radiation heat exchange. Radiation shields. Conduction shape factor.	**10**
4	**Mass Transfer** Introduction to mass transfer – diffusion coefficient – Fick's law of	**8**

	diffusion- steady state diffusion in stationary medium- diffusion in moving medium- diffusion through a membrane. Convective mass transfer – non dimensional numbers – analogy between heat and mass transfer – correlations. Cooling of electronic equipments – need – various methods – influencing factors. Electric battery cooling – various methods - phase change material, fin cooling, air cooling, liquid cooling. (description only)	

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

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

SEMESTER S5

MANAGEMENT FOR ENGINEERS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

PBL Course Elements

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

Assessment and Evaluation for Project Activity

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

1. Project Planning and Proposal (5 Marks)

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

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

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

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

- Active participation and individual contribution
- Teamwork and collaboration

4. Execution and Implementation (10 Marks)

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

5. Final Presentation (5 Marks)

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

6. **Project Quality, Innovation, and Creativity (3 Marks)**
   - Overall quality and technical excellence of the project
   - Innovation and originality in the project
   - Creativity in solutions and approaches

SEMESTER S5

COMPUTATIONAL FLUID DYNAMICS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S5

DESIGN FOR MANUFACTURE AND ASSEMBLY

Course Code	**PEMET522**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Manufacturing Process PBMET304	**Course Type**	Theory

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S5

COMPUTER AIDED DESIGN AND ANALYSIS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S5

ADDITIVE MANUFACTURING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S5

ENERGY ECONOMICS AND POLICY

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

Course Objectives:

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

SYLLABUS

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

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

	acceptance. Energy efficient policies to achieve SDGs for countries, Importance of Conference of parties (COP). Energy Policy: A Foundation for Transition-Energy Transition: A Paradigm Shift, Future Prospects and Emerging Trends, The Link Between Energy Policy, Energy Transition, and Sustainability in Oil-Rich Countries, Energy Policy Research A Pathway to Achieve UN (SDGs).The Role of COP in Emission Abatement, COP Goals, Agenda, Major Outcomes of COP	**9**

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

SEMESTER S5

HUMAN RESOURCES MANAGEMENT

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S5

OPERATIONS RESEARCH

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

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

SEMESTER S5

INSTRUMENTATION AND CONTROL SYSTEMS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S5

THERMAL ENGINEERING LAB-1

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

Course Objectives:

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

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Measure thermo-physical properties of solid, liquid and gaseous fuels	**K4**
CO2	Evaluate thermal properties of materials in conduction, convection and radiation	**K4**
CO3	Analyse the performance of heat exchangers and heat pipes	**K4**
CO4	Illustrate the operational performances of refrigeration and air conditioning systems	**K2**
CO5	Measure solar radiation	**K4**

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

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

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

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

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

Continuous Assessment (25 Marks)

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

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

4. **Viva Voce (10 Marks)**

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

5. **Record (5 Marks)**

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

SEMESTER S5

MECHANICAL ENGINEERING LAB

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

Course Objectives:

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

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

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

A minimum of 12 sets of experiments are mandatory

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

Continuous Assessment (25 Marks)

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

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

2. Conduct of Experiments (7 Marks)

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

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

3. Lab Reports and Record Keeping (6 Marks)

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

4. Viva Voce (5 Marks)

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

4. Viva Voce (10 Marks)

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

5. Record (5 Marks)

- Completeness, clarity,

SEMESTER 6

MECHANICAL ENGINEERING

SEMESTER S6

INDUSTRIAL AND SYSTEMS ENGINEERING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

SEMESTER S6

MACHINE DESIGN

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

Text Books

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

Data Books permitted for reference in the final examination:

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

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

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

SEMESTER S6

POWER PLANT ENGINEERING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107291/
2	https://archive.nptel.ac.in/courses/112/107/112107291/
3	https://archive.nptel.ac.in/courses/112/107/112107291/
4	https://archive.nptel.ac.in/courses/112/107/112107291/

SEMESTER S6

COMPRESSIBLE FLUID FLOW

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

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

SEMESTER S6

INDUSTRIAL TRIBOLOGY

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

Text Books

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

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Surface Engineering for Corrosion and Wear Resistance	J.R. Davis	ASM International	First,2001
2	Lubrication and Lubricant Selection: A Practical Guide	A. R. Lansdown	ASME	Third,2003
3	Tribology for Scientists and Engineers	Pradeep L. Menezes, Siddhartha Ghosh, and BijoyBhushan	Springer	First,2013
4	Advanced Tribology: Proceedings of CIST2008 & ITS-IFToMM2008	JianbinLuo, YonggangMeng, Tianmin Shao, and Qian Zhao	Springer	2010

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/102/112102014/
2	https://archive.nptel.ac.in/courses/112/102/112102014/
3	https://archive.nptel.ac.in/courses/112/102/112102014/
4	https://nptel.ac.in/courses/113108083

SEMESTER S6

FINITE ELEMENT METHODS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/112106135
2	https://nptel.ac.in/courses/112106135
3	https://nptel.ac.in/courses/112106135
4	https://nptel.ac.in/courses/112106135

SEMESTER S6

NON – DESTRUCTIVE TESTING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
I to IV	https://archive.nptel.ac.in/courses/113/106/113106070/

SEMESTER S6

INDUSTRIAL SAFETY ENGINEERING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/110105094
2	https://nptel.ac.in/courses/110105094
3	https://nptel.ac.in/courses/110105094
4	https://nptel.ac.in/courses/110105094

SEMESTER S6

MARKETING MANAGEMENT

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/104/110104068/
2	https://archive.nptel.ac.in/courses/110/104/110104068/
3	https://archive.nptel.ac.in/courses/110/104/110104068/
4	https://archive.nptel.ac.in/courses/110/104/110104068/

SEMESTER S6

ADVANCED MATERIALS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

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

SEMESTER S6

THERMAL ENGINEERING

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

Course Objectives:

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

SYLLABUS

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

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

Suggestion on Project Topics

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

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

PBL Course Elements

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

Assessment and Evaluation for Project Activity

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

1. **Project Planning and Proposal (5 Marks)**

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

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

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

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

    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

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

5. **Final Presentation (5 Marks)**

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

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

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

SEMESTER S6

INTRODUCTION TO BUSINESS ANALYTICS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of business analytics and how it is becoming competitive strategy for many organisations.	**K2**
CO2	Understand the Importance of analytics in decision making and problem solving.	**K2**
CO3	Understand the application of descriptive analytics in decision making.	**K2**
CO4	Learn data visualization and various types of visual charts.	**K2**
CO5	Apply simple linear regression model in predictive analytics problems.	**K3**
CO6	Understand the basic concepts in prescriptive analytics.	**K2**
C07	Understand the essence of business performance management and analytics in business support functions.	**K2**

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

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

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

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/YZf5q-ICf8Y
2	https://youtu.be/1MiT06JFNo4 and https://youtu.be/6lQn1hdG43o
3	https://youtu.be/eY55ocm-VgM and https://youtu.be/xXDoZLVjfbs

SEMESTER S6

QUANTITATIVE TECHNIQUES FOR ENGINEERS

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

SEMESTER S6

AUTOMOTIVE TECHNOLOGY

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

Course Objectives:

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

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction**: History of automobiles: Electric, Hybrid and Internal Combustion Engines (ICE) vehicles – classification of automobile L, M and N category. Sub division according to body style (hatchback to station wagon). Basic vehicle dynamics: Rolling, Air and Grade resistance, Power and Torque for propulsion (basic equations). Different ICEs – SI & CI, Single and multicylinder with arrangements, Bi fuel & dual fuel, latest technologies in ICEs – Flex fuel vehicles, H_2-ICE, Hybrid types – Mild & strong hybrids, series, parallel, and series parallel types.	9

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the efficiency and performance of different automotive propulsion systems (electric, hybrid, internal combustion)	**K2**
CO2	Apply knowledge of automotive components to diagnose and troubleshoot issues in propulsion, transmission, and chassis systems.	**K3**
CO3	Describe the operation and integration of advanced automotive technologies such as fuel injection systems and electronic control units (ECUs) in vehicle design and performance enhancement.	**K2**
CO4	Understand basics of E & E architecture and principles behind vehicle handling and safety through analysis of steering, braking and suspension systems.	**K2**

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

CO-PO Mapping Table:

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/107/106/107106088/
2	https://archive.nptel.ac.in/courses/107/106/107106088/
3	https://archive.nptel.ac.in/courses/107/106/107106088/
4	https://archive.nptel.ac.in/courses/107/106/107106088/

SEMESTER S6

RENEWABLE ENERGY ENGINEERING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1 to 4	https://nptel.ac.in/courses/103103206

SEMESTER S6

QUALITY ENGINEERING AND MANAGEMENT

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/110105088
2	https://nptel.ac.in/courses/110101010
3	https://nptel.ac.in/courses/110101010
4	https://nptel.ac.in/courses/110101010

SEMESTER S6

ADDITIVE MANUFACTURING

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

Course Objectives:

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

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

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

SEMESTER S6

SOLAR ENERGY CONSERVATION SYSTEMS

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

Course Objectives:

1. To equip students with a thorough understanding of solar radiation, the sun-earth relationship, and the atmosphere's impact, and to provide detailed knowledge of different solar collectors, their thermal analysis, tracking mechanisms, and storage solutions.

2. To enable students to understand PV systems' principles and performance, including design and components of standalone and grid-connected systems, and to introduce methods of economic evaluation of solar energy technologies, such as cost analysis, payback period calculation, and financial feasibility in the context of energy policy.

SYLLABUS

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

CO-PO Mapping Table:

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

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

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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/104/112104300/
2	https://archive.nptel.ac.in/courses/112/104/112104300/
3	https://archive.nptel.ac.in/courses/115/103/115103123/
4	https://archive.nptel.ac.in/courses/115/103/115103123/

SEMESTER S6

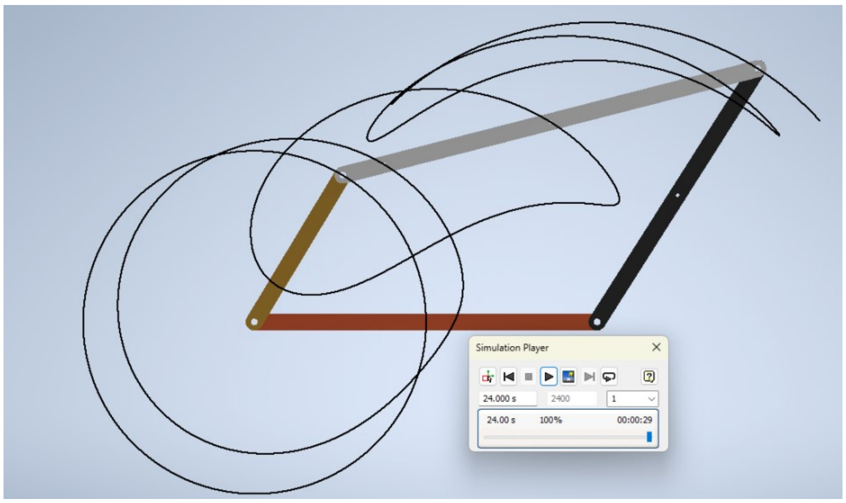
COMPUTER AIDED DESIGN AND ANALYSIS LAB

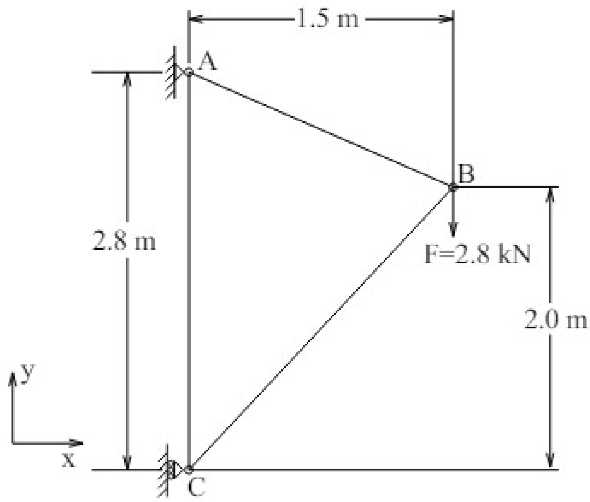
Course Code	**PCMEL607**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Computer Aided Machine Drawing (Course code - PCMEL307)	**Course Type**	Lab

Course Objectives:

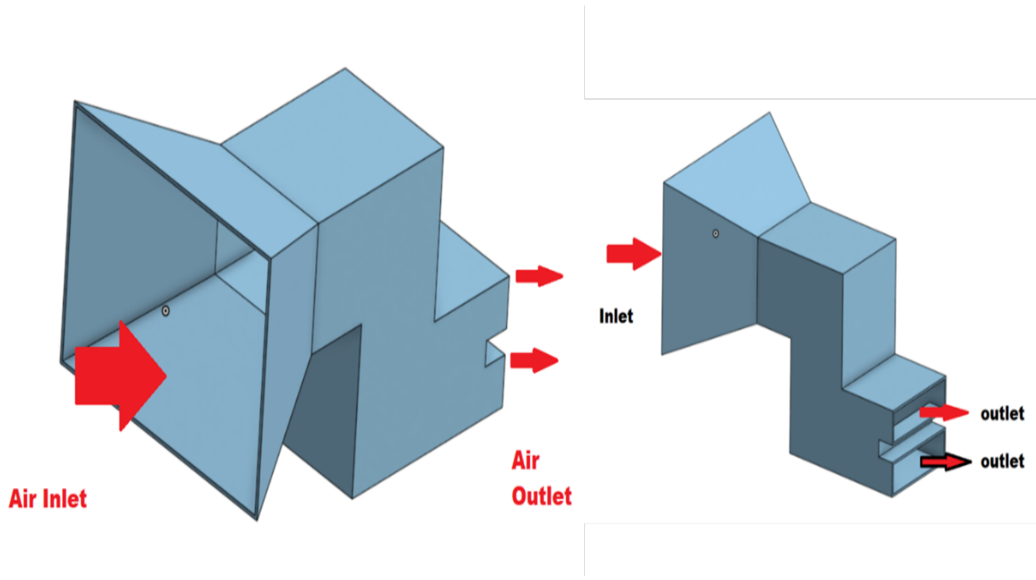
1. Teach students to design and simulate mechanical systems using CAD and FEA software. This includes creating mechanisms like the Whitworth quick return and four-bar linkage, and analyzing structural elements such as bars and trusses.
2. Enable students to perform dynamic simulations and analyze mechanical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

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

	follower at crank angles of 30°, 60°, and 90°. Begin by modeling the four-bar mechanism, setting up the simulation with appropriate joints, and running the simulation over a complete cycle of the crank. Trace and document the specified coupler curves, plot the velocity and acceleration curves of the follower, and tabulate the velocity and acceleration values at the specified crank angles. Submit a comprehensive report including the 3D model, plots, and a brief discussion on the findings. 
2	Design and Simulation of a Whitworth Quick Return Mechanism Design and simulate a Whitworth quick return mechanism with a specified quick return ratio. Analyze and plot the Coriolis component of acceleration, as well as the position of the slider in the slotted lever, acceleration and position ofthe tool ram throughout the mechanism's cycle.
3	Perform a structural analysis of an axial bar with varying cross-sectional areas under axial load using FEA software to determine the stress distribution, strain distribution, and total deformation. Example Problem Description: An axial bar of length L=1m is subjected to an axial tensile load P=10kN. The bar has three different cross-sectional areas along its length:Section 1: From x=0 to 0.3m, the cross-sectional area is A1 $=50mm^2$, Section 2: From x=0.3m to x=0.7m, the cross-sectional area is A2 $=75mm^2$, Section 3: From x=0.7m to x=1.0m, the cross-sectional area is A3 $=100mm^2$. The bar is fixed at the end with the smallest cross-sectional area (Section 1).
4	Perform a structural analysis of a truss using FEA software to determine the force in each member, identify if the members are in tension or compression, and calculate the

	support reactions. Example Problem Description: Analyze the given truss structure. The cross-sectional area of each truss member is $0.01m^2$,the material of the truss members is steel with a Young's Modulus $E = 2.1\times10^5$ MPa.  Figure 1: Geometry of the truss.
5	Perform the structural analysis of a thin plate (plane stress case) subjected to in plane loads
6	Perform the modal analysis of a cantilever beam
7	Perform the harmonic analysis of a cantilever beam
8	Perform an Eigen-buckling analysis using FEA software. Example Problem Description: Conduct an Eigenbuckling Analysis of a column with I-section using a FEM software to determine the shape numbers and load multipliers for the column. Compare the results obtained with Euler's critical buckling load formula. Additionally, provide the following results: the critical buckling load, the mode shapes, the corresponding displacements, and the stress distribution for each mode.
9	Perform a fatigue analysis using FEA software. Example Problem Description: Perform a fatigue analysis on a Formula SAE hub subjected to a torque of 300 N-m and a dead load of 700 N per wheel. Determine the number of cycles to fatigue failure for the

	hub under these specified loading conditions.
10	Solve a steady-state heat conduction problem using FEA software to determine the temperature distribution within a solid material. Example Problem Description: Consider a rectangular solid plate with dimensions L = 200 mm (length), W =100 mm(width), and t =10 mm (thickness). Material Properties given, Thermal conductivity, k 50 W /mK, Density, ρ = 7800 kg/m3, Specific heat capacity, C = 500 J/kgK. Boundary Conditions: Left edge (x= O mm): Maintained at a constant temperature T_1=100 C. Right edge (x= 200 mm): Maintained at a constant temperature T_2 =50 C. Top and bottom surfaces (y = O mm and y = 100 mm): Insulated (no heat flux). Front and back surfaces (z = O mm and z= 1O mm): Insulated (no heat flux).
11	Perform a transient heat transfer analysis of a solid fin subjected to natural convection using FEA software to determine the temperature distribution and heat transfer over time. Example Problem Description: Consider a rectangular solid fin made of aluminum with dimensions: length L 100 mm, width W 50 mm, and thickness t 5 mm. The fin is made of aluminum, having a thermal conductivity of k =237 W /mK, density of ρ= 2700 kg/m^3 , and a specific heat capacity of C= 900 J/kgK. Initially, the fin is at a uniform temperature of To = 25^0C. One end of the fin (x = 0 mm) is subjected to a constant heat flux of q = 2000 W /m^2, while the surrounding air temperature is T_{sur} = 25 ^{0} C with a convective heat transfer coefficient h = 10W/m^2 K on all other surfaces. Perform a transient thermal analysis for a duration of t= 3600 s (1 hour) with appropriate time steps. The analysis aims to determine the temperature distribution and heat transfer in the fin at various time intervals, including contour plots showing the temperature distribution at different intervals and values of temperature at key points, the base (near O mm), the tip (x= 100 mm), and the midpoint (x=50 mm). The results should include the total heat transfer rate from the fin to the surrounding air and heat flux distribution plots at the specified time intervals.
12	Perform the 2D flow analysis of an airfoil

<table>
<tr>
<td>13</td>
<td>Perform a flow analysis to improve the design of an air intake manifold for a pneumatic device by analyzing flow separations and recirculation zones using flow analysis
software

</td>
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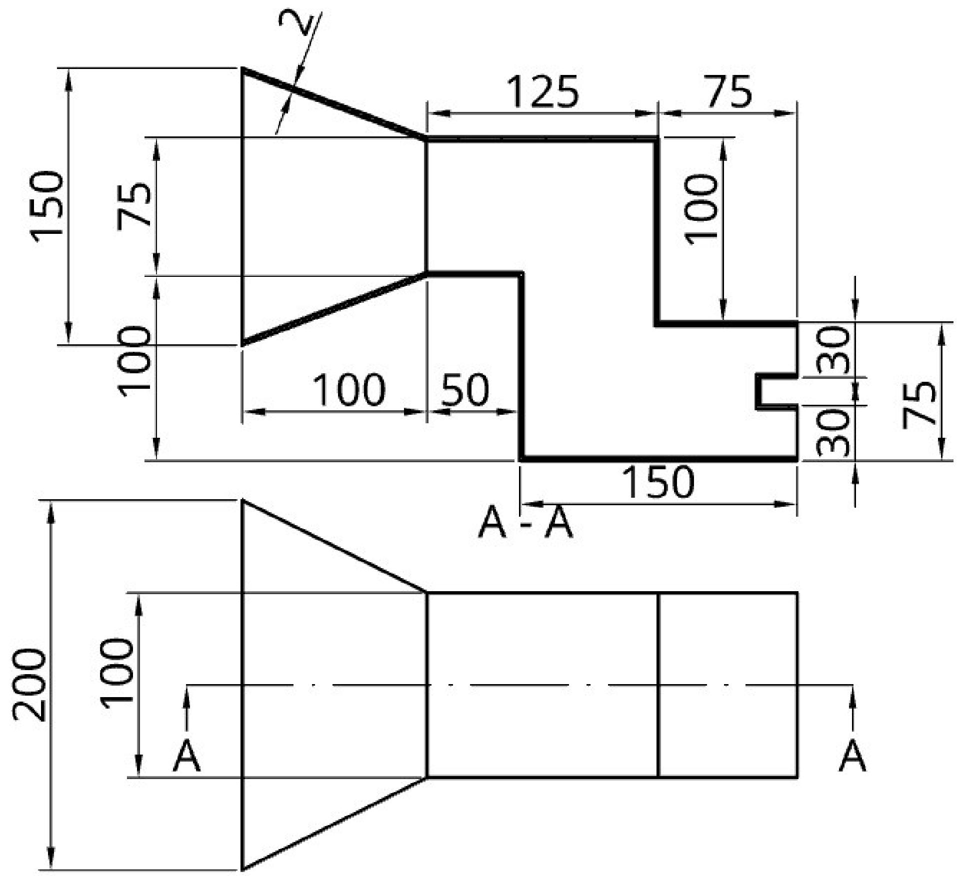
</table>



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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

Continuous Assessment (25 Marks)

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

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

4. Viva Voce (10 Marks)

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

5. Record (5 Marks)

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

SEMESTER S6

THERMAL ENGINEERING LAB-2

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

Course Objectives:

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

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

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

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE):

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

Continuous Assessment (25 Marks)

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

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

2. **Conduct of Experiments (7 Marks)**

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

3. **Lab Reports and Record Keeping (6 Marks)**

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

4. **Viva Voce (5 Marks)**

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

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

Evaluation Pattern for End Semester Examination (50 Marks)

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

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

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

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

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

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

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

4. Viva Voce (10 Marks)

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

5. Record (5 Marks)

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

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	10thedition, 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	9thedition, 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 SO_2- 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/

SEMESTER 8

MECHANICAL ENGINEERING

SEMESTER S8

CRYOGENIC ENGINEERING

Course Code	PEMET861	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. Understand the Fundamental Principles and Applications of Cryogenic Engineering
2. Analyse and Evaluate the Performance of Cryogenic Systems and Components

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to cryogenic engineering - Historical background - Major events in the development of cryogenic engineering. Low Temperature Properties of Engineering Materials - Mechanical properties, Thermal properties, Electric and magnetic properties. Cryogenic fluids (N_2, O_2, H_2, He, Ar, Ne, CH_4) and their properties. Applications of cryogenics - Applications in space, food processing, superconductivity, electrical power, biology, medicine, electronics, quantum computing, and manufacturing industry.	9
2	Cryogenic Liquefaction systems – System performance parameters, ideal liquefaction system, Joule-Thomson expansion, Adiabatic expansion. Liquefaction systems for gases other than Neon, Hydrogen and Helium- Simple Linde - Hampson system, Claude, Cascade System, and Auto-cascade system.	9

	Liquefaction systems for Neon, Hydrogen and Helium – LN_2 precooled Linde Hampson and Claude systems, Ortho to Para conversion arrangement in hydrogen liquefaction system, Simon Helium liquefaction system, Collins Helium liquefaction system. Critical components of Liquefaction systems – critical components, types of heat exchanger used in cryogenic systems and their effect on system performance.	
3	Cryogenic Refrigeration systems- Ideal isothermal and isobaric refrigeration systems, Refrigeration using liquids as refrigerant- Linde-Hampson refrigerator, Claude refrigerator. Refrigeration using gases as refrigerant- Stirling cycle cryocoolers, Philips refrigerator, Effect of regenerator effectiveness on performance of the Philips refrigerator, Gifford McMahon refrigerators, Pulse tube cryocoolers. Refrigerators using solids as working media-Magnetic refrigerators – Thermodynamics of magnetic refrigerators, dilution refrigerators.	**9**
4	Cryogenic fluid storage and transfer systems-Cryogenic fluid storage vessel, Thermal insulations and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems, Cryo pumping. Cryogenic instrumentation, Pressure measurement – Mc Leod gauge, Pirani gauge, and Penning gauge, Flow measurement – Orifice meter, Venturi meter, and Turbine flow meter. Liquid level gauges-hydrostatic, resistance gauge, capacitance gauge, and thermodynamic gauge, Temperature measurements- ITS-90, Thermocouple, RTD, magnetic thermometers, and vapor pressure thermometers, Safety in cryogenic fluid handling, storage and use.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe and analyse the mechanical, thermal, electrical, and magnetic properties of engineering materials at cryogenic temperatures and determine their suitability for various applications.	**K1, K2**
CO2	Identify and explain the properties of common cryogenic fluids and evaluate their applications in various industries	**K1, K2**
CO3	Analyse and compare different cryogenic liquefaction systems	**K2, K3**
CO4	Analyse and compare different cryogenic refrigeration systems	**K2, K3**
CO5	Demonstrate knowledge of cryogenic instrumentation techniques for pressure, flow, and temperature measurement and safety protocols for the handling, storage, and use of cryogenic fluids	**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	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	-	-	-	-	-	-	-	-	-
CO4	3	3	3	-	-	-	-	-	-	-	-	-
CO5	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cryogenic systems	Randal F. Barron	McGraw Hill	1986
2	Fundamentals of Cryogenic Engineering	M Mukhopadhyay	PHI Learning	2010
3	Cryogenic Process Engineering	K. D. Timmerhaus and T.M. Flynn	Springer	2013
4	Cryogenics	S.S Thipse	Narrosa	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cryogenic Mixed Refrigerant Processes	G Venkatarathnam	International Cryogenics Monograph Series, Springer International Publishing	2007
2	Cryocoolers: Theory and Applications	M. D. Atrey (Ed)	International Cryogenics Monograph Series, Springer International Publishing	2020
3	Cryogenic Technology and applications,	A. R. Jha,	Elsevier Science	2011

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-IV	Cryogenic Engineering, Prof. M D Atrey, IIT Bombay https://nptel.ac.in/courses/112101004

SEMESTER S8

PRESSURE VESSEL AND PIPING DESIGN

Course Code	PEMET862	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 present the industrial related problems, procedures and design principles for pressure vessels and enhance the understanding of design procedure of pressure vessel and Design of piping layout.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Pressure vessel – Terminology – Types of loads – Types of pressure- Types of supports. Stresses in pressure vessels – Dilation of pressure vessels. Membrane stress analysis of vessel shell components- cylindrical shells, spherical shells, torus, conical head, elliptical head, (Familiarisation of corresponding ASME section 8 codes for membrane stress equations)) Discontinuity stress analysis in pressure vessels.	9
2	Stresses in thick-walled cylinders –Lame's equation for internal and external pressure, Shrink-fit stresses in Built up cylinders, auto frettage of thick cylinders. Theory of reinforced opening (Familiarisation of corresponding ASME section 8 codes for reinforcement analysis)	9
3	Design of tall vessel under wind and seismic load. Design of leg, lug and saddle supports. Buckling -Analysis of Elastic buckling of cylinders or pipes under external pressure- Design of Stiffeners for pressure vessel (Use relevant ASME codes and standard practices in pressure vessel	9

	design for the entire third module)	
4	Pipes- Size and wall thickness specification, Type of pipes based on manufacturing technique. Piping components - bends, tees, elbows, reducers, bellows, flanges and valves. Stress Analysis, sizing and thickness calculation of pipes (Familiarise with ASME B31.3). Allowable and displacement stress range for expected cyclic life-stress intensification factor- Flexibility Analysis (Analysis as per clause 119.7.1 in Code ASME B31.1/clause 319.4.1 in ASME B31.3 only)	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	Explain the design considerations of various shell type pressure vessels	**K2**
CO2	Explain the design considerations of thick cylinders under various kind of loadings	**K2**
CO3	Apply design concepts in the design of shell and supports of vertical and horizontal pressure vessels and solve problems involving the thickness and stiffener support requirements of cylinders under buckling loads	**K3**
CO4	Solve problems involving pipe stress and flexibility analysis and also understand the fracture based design concepts of pressure vessels	**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	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	-	-	-	-	-	-	-	-	-
CO4	3	3	3	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Theory and Design of Pressure Vessels	John F. Harvey	CBS Publisher and Distributors	
2	Process Equipment Design	Brownell, L. E., and Young, E. H.,	John Wiley and Sons	
3	Pressure Vessels Design and practice	SomnathChathopadhyay	C. R. C Press	
4	Pressure vessel design handbook	Eugene F megyesy	Pressure vessel publishing Inc	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Pressure Vessel Design Manual	Dennis R. Moss,	Elsevier Inc	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc23_ch69/preview
2	https://onlinecourses.nptel.ac.in/noc23_ch69/preview
3	https://onlinecourses.nptel.ac.in/noc23_ch69/preview
4	https://onlinecourses.nptel.ac.in/noc23_ch69/preview

SEMESTER S8

HYBRID AND ELECTRIC VEHICLES

Course Code	**PEMET863**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To understand the basic concepts of hybrid and electric vehicles.
2. To study the various energy storage and propulsion systems of hybrid and electric vehicles.
3. To study the various motor drives and controllers of hybrid and electric vehicles.

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	Vehicle fundamentals – general description, vehicle resistances, tractive effort, vehicle performance - maximum speed, power, gradability, etc. Electric vehicles – introduction, history, social and environmental importance of hybrid and electric vehicles, Types of EVs. EV transmission – configurations – front wheel drive and rear-wheel drive. Traction motor characteristics and comparison with IC engine characteristics. Hybrid electric vehicles – concept, architecture, classification, series, parallel, series-parallel and complex, hybrid drivetrains, the configuration of the series hybrid electric drive train, the configuration of the parallel hybrid electric drive train.	**9**

2	Energy storage – Battery basics, battery parameters, battery technologies - Lead-Acid Battery, Nickel-Cadmium Battery, Nickel-Metal-Hydride (NiMH) Battery, Li-Ion Battery, Li-Polymer Battery. Alternative energy sources – fuel cell, supercapacitors and ultracapacitors, flywheel (Overview only). Battery pack design, battery management system (BMS), sensors used in BMS, thermal management systems of battery, battery safety standards in India, AIS 156 (2020) and AIS 038 Rev (2020). EV charging – types, layout of AC and DC chargers, different charging protocols-CHAdeMO, CCS2, GB/T, battery swapping.	**9**
3	Electric propulsion system – electric motors, classification, induction motors, basic principles and construction, torque–slip characteristics. Permanent magnets, ferrite, SmCo and NdFeB types, PM motors-BLDC, PMSM, basic principles and construction, switched reluctance motors (SRM), basic principles and construction. Regenerative braking – principle, block diagram. Gearbox, selection of gear ratio, Different kinds of gearboxes. EV motor sizing – need of gearbox.	**9**
4	Motor controllers – motor drive components, power electronic switches, MOSFET and IGBT, bidirectional switch. Induction motor controls – constant speed/frequency control, variable DC/AC inverter with sinusoidal PWM, field orientation control. BLDC motor controls – torque control and speed control methods, principles and block diagrams. SRM drive converter - classical half-bridge converter. Vehicle Sensors specific to EV sensors interfaced to the ECU's in the vehicle network. Controller Area Networking (CAN) – frame types of CAN, layered architecture of CAN.	**9**

	Vehicle Validation - 6 levels of EV validations. Advances in electric and hybrid vehicle technology – autonomous driving, connected vehicles (overview only).	

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

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the general architecture of Electric vehicles.	**K2**
CO2	Describe various battery, charging types and battery management of Electric vehicles.	**K2**
CO3	Describe various motors and drives of Electric vehicles.	**K2**
CO4	Explain details of power transmission of Electric vehicles and select the appropriate components based on requirement.	**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	2					3
CO2	3	1				1						3
CO3	3					1						3
CO4	3					1						2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electric and Hybrid Vehicles": Design Fundamentals	Iqbal Husain	CRC press	2nd edition, 2010
2	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design	Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi	CRC press	3rd edition, 2018
3	Electric Vehicle Technology Explained	James Larminie, John Lowry	Wiley-Blackwell	2nd edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electric and hybrid vehicles	Denton T.	CBS Publishers & Distributors Pvt. Ltd.	2nd edition, 2020
2	Electric Vehicle Battery Systems	Dhameja S.	Newnes (an imprint of Butterworth-Heinemann Ltd)	2001

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108106170
2	https://nptel.ac.in/courses/108106170
3	https://onlinecourses.swayam2.ac.in/ntr24_ed54/preview
4	https://onlinecourses.swayam2.ac.in/ntr24_ed54/preview

SEMESTER S8

MICRO AND NANO MANUFACTURING

Course Code	**PEMET864**	**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. To give awareness of different techniques used in micro and nano manufacturing
2. To give in-depth idea of the conventional techniques used in micro manufacturing
3. To introduce Non-conventional micro-nano manufacturing and finishing approaches
4. To introduce Micro and Nanofabrication Techniques and other processing routes in
5. Micro and nano manufacturing
6. To know different techniques used in Micro Joining and the metrology tools in micro and nano manufacturing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Precision engineering, Introduction to macro, meso, micro, and nano manufacturing - Classification —**Traditional Mechanical Micromachining Process**: Micro Turning, Micro Drilling, Micro Grinding, High-Speed Machining – Micro tools**.** Diamond micro turning- principle, process, description and applications. **Mechanical type micromachining processes -** Abrasive based nano finishing process Introduction to **beam energy based micro machining processes-** Ultrasonic micro machining, Focused Ion Beam machining, Laser Beam micro machining.	**10**

	Thermo-Electric type micromachining processes - Chemical and Electro-Chemical Type Advanced Machining Processes	
2	**Micro forming techniques**: laser micro-bending, micro-deep drawing, and micro-extrusion, Micro moulding processes: Injection moulding, hot embossing - micromolding tools-applications. Micro welding and joining techniques: Laser micro welding- Electron Beam Micro welding. **Micro/ Nano finishing processes-** Abrasive Flow Machining, Magnetic Abrasive Finishing, Magneto Rheological Abrasive Flow Machining, Magneto Rheological Finishing. Elastic Emission machining (EEM), IonBeam Machining (IBM), Chemical Mechanical Polishing (CMP)- principle, equipment and applications **Hybrid micro/nano machining** – Electro Chemical Spark Micro Machining, Electro Discharge Grinding, Electrolytic in Process Dressing Grinding. **Laser technology in micro manufacturing-** Practical Lasers, application of technology fundamentals.	**10**
3	**Characterizing etching processes in bulk micromachining**; basics of micro-fabrication, integrated circuit fabrication; crystallography and its effects, silicon as substrate and structural material, stress and strain, crystal plane effects on etching, wet etching process, reaction phenomena, anisotropic etching, isotropic etch curves, masking for anisotropic etchants, etching control, fusion bonding of silicon on an insulator, deep reactive ion etching, fabrication of a cantilever probe, manufacture, microprocessors and applications; problems with etching in bulk micromachining. **Micro fabrication Techniques:** Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Micro-fabrication using deposition techniques: epitaxial, sputtering, chemical vapour deposition (CVD) techniques. Bulk Micromachining, Surface Micromachining, High- Aspect- Ratio Micromachining, Photolithography, LIGA process.	**12**
4	**Introduction to Nanofabrication**, Nanofabrication using soft lithography – principle, applications – Examples (Field Effect Transistor, Elastic Stamp) e-Beam Nanolithography – important techniques, Introduction to Nanotechnology. **Principle of the soft lithography** and applications; principle of micro	**12**

	contact printing and applications; characterizing the surface micromachining process, isolation layer, sacrificial layer, structural material, selective etching – properties, stress, stress measurement, friction; wafer bonding: anodic and fusion, bonding. **Manipulative techniques** – process principle, applications. **Introduction toCarbon nano materials** — properties and applications, Carbon Nanotubes Transistors – (Description only) Diamond - Properties and applications, CVD Diamond Technology. **Introduction to micro-nano inspection and metrology-** Scanning electron microscopy- principle and description, Scanning white light interferometry- principle and description. Optical microscopy- principle and description. Scanning probe microscopy, Scanning tunnelling microscopy- principle, description and applications. Confocal microscopy, Atomic force microscopy- principle and description. Introduction to On-machine metrology.	

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain different techniques used in micro and nano manufacturing	**K2**
CO2	Describe conventional techniques and non-conventional micro-nano manufacturing approaches	**K2**
CO3	Outline the working principle and applications of micro and nano finishing processes	**K2**
CO4	Explain the basics of micro and nano fabrication techniques	**K2**
CO5	Select a suitable Metrology for measurement of dimensional, form, and surface integrity of components manufacturing using micro and nano Manufacturing	**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	-	2	1	1	-
CO2	3	-	-	-	-	-	1	-	2	1	1	-
CO3	3	-	-	-	-	-	1	-	2	1	1	-
CO4	3	-	-	-	-	-	1	-	2	1	1	-
CO5	3	-	-	-	1	-	2	-	2	1	1	1

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Microfabrication and Nano manufacturing	Mark J. Jackson	Taylor and Francis-CRC press	2006
2	Micro manufacturing Processes	Jain V.K	CRC Press	2012
3	Nano Materials	Bandyopadhyay A.K	New Age International Publishers, New Delhi	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Micro and Nano manufacturing	Mark. J. Jackson	Springer	2007
2	Introduction to Micromachining First edition	Jain V.K	Narosa publishing house	2017
3	MEMS and microsystems: design, manufacture, and nanoscale engineering	Hsu, Tai-Ran	John Wiley & Sons	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtube.com/playlist?list=PLB8BC0AB0AD5DA4E2&si=5K0kjXdseqlVUSxq
2	https://youtu.be/YJ5OhYLbeSE?si=uzqWytqgjRbI5I1i
3	https://youtube.com/playlist?list=PLgMDNELGJ1CbHti4HN0BuagtoD06H78YT&si=R-34kA6jB8QL-bKN
4	https://youtu.be/TbYU8df53V4?si=vck_ULHZL908ZmHK

SEMESTER S8

ADVANCED NUMERICAL CONTROL IN MANUFACTURING

Course Code	**PEMET866**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To know the operational difference between NC and CNC systems
2. To understand the controlling elements in CNC machines
3. To learn the programming used in CNC machines

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Principles of Numerical Control Structure of NC systems, Applications of CNC machines in manufacturing, Advantages of CNC machines. Historical developments and future trends. Future of NC Machines, Difference between ordinary and NC Machine tools, Machining Capabilities of a CNC Machine, Methods for improving accuracy and productivity. Control of NC Systems: Classification of CNC control systems Open and Closed loop systems, Types of CNC Machine Tools systems devices.	**9**
2	Encoders and interpolators, Features of CNC Systems, Direct Numerical Control (DNC), Standard Controllers and General Programming features available in CNC Systems, Computer Process monitoring and Control. Adaptive control systems.	**8**
3	NC Part Programming: Axis identification and coordinate systems, Structure of CNC part program, Programming codes, Programming for 2 and 3 axis control systems, Manual part programming for a turning center, Programming using tool nose radius compensation, Tools offsets, Do loops,	**10**

	sub routines and fixed cycles. Manual Programming for simple parts.	
4	Computer aided part programming; Tools for computer aided part programming, Computer aided NC Programming in APT language, use of canned cycles, Generation of NC Programmes through CAD/CAM systems, Design and implementation of post processors. Constructional Details of CNC Machines: Machine structure, Slide –ways , Motion transmission elements , Swarf removal and safety considerations , Automatic tool changers and multiple pallet systems, Sensors and feedback devices in CNC machines.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the working of NC and CNC systems	**K2**
CO2	Understand feedback mechanisms in CNC machines	**K2**
CO3	Create programming code in CNC	**K6**
CO4	Understand the construction details of CNC machines	**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	-	-	-	-	-	-	-	-	-	-	-
CO2	3-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	2	2	-	2	-	-	-	1	-	-	-
CO4	3	2	2	-	-	-	-	-	1	-	-	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Numerical Controls in Manufacturing	Frank W Wilson	McGraw-Hill	1963
2	Introduction to Numerical Control in Manufacturing	American Society of Tool and Manufacturing Engineers, Chester Joseph Kishel	American Society of Tool and Manufacturing Engineers,	1969

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Control of Manufacturing Systems	Yoram Koren	McGraw-Hill Inc.,US	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/112/105/112105211/

SEMESTER S8

METAL ADDITIVE MANUFACTURING

Course Code	**PEMET867**	**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. To understand IoT and digital manufacturing demands for quicker and modular manufacturing solutions
2. To familiarise the current status of metal AM basics, materials, processes, and major important related aspects.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Additive Manufacturing (AM)– Process, Materials, Applications- Modular Design and Topology–Customization, Efficiency, Scalability - Design freedom in AM– Complex Geometries, Lightweight Structures, Material Efficiency -Benefits of Topology Design Freedom–Performance Enhancement, Innovation, Sustainability	9
2	CAD for AM, Integration of CAD with Additive Manufacturing, Design for AM, Topology Optimization, Metal AM physics and processes – PBF, DED, Binder Jetting, Sheet Lamination. Laser and Extrusion – SLS, SLM, DMLS, FDM, Robocasting. Metal AM processes, Filament, Powder and Sheet Systems, Metal AM as an Extension of Welding Techniques (GTAW/GMAW).	9
3	Metal AM physics and processes, Directed Energy, Binder and Material Jetting Feedstocks, Metallurgy and properties of materials– Microstructure, Mechanical, Thermal and Chemical Properties, Post processing and testing –	9

	Heat Treatment, Hot Isostatic Pressing, Machining, Surface Treatment and NDT Methods.	
4	Reverse Engineering for metal AM, Data Handling, Simulation and Analysis, Modelling for AM –Support Structures, Functional Integration, Value analysis – Cost, Time, Performance and Sustainability -Future of metal AM	**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 study the basic Metal Additive Manufacturing Techniques	**K2**
CO2	To understand the features and control of various MAM Methods	**K2**
CO3	To familiarize the metallurgy of MAM Processes.	**K3**
CO4	To study the relation between reverse engineering and additive manufacturing.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	2	-	-	-	-	-	-	-	-	2
CO2	2	-	-	-	3	-	-	-	-	-	-	2
CO3	3	-	-	-	-	-	-	-	-	-	-	2
CO4	3	-	-	-	-	2	-	-	-	-	-	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing of Metals: The Technology, Materials, Design and Production	Li Yang, Pan Michaleris	Springer	

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Additive Manufacturing of High-Performance Metals and Alloys	Robert Pederson, Matthew S. Sokolov, Chao Ma	IntechOpen	
2	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing	Ian Gibson, David W. Rosen, Brent Stucker, MahyarKhorasani	Springer	

Video Links (NPTEL, SWAYAM…)	
Module No.	Link ID
1	https://youtu.be/hOkV4Uo_w2Y
2	https://youtu.be/G9T9MkbjB68
3	https://youtu.be/_V_CUDPSzJE
4	https://youtu.be/EyEg57tlS1k

SEMESTER S8

NANOTECHNOLOGY

Course Code	PEMET868	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. Develop an understanding of nanomaterials and properties
2. Apply nanomaterials and engineering solutions to new technologies

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Nanoscience and technology: Introduction, brief history, Discussion on Fayman's talk, size effect, anomalous behavior of materials at nanoscale, impact of nanoscale on various properties of materials (structural, mechanical, thermal, optical, electronic), applications, examples from nature	9
2	Fabrication of Nanomaterials, Top-down and Bottom-up approaches Top-down fabrication: Mechanical methods, thermal methods, High energy methods, Chemical and lithographic methods Bottom-up methods: gaseous phase methods, liquid phase methods, solid bottom-up methods, Template synthesis	9
3	Carbon-based nanomaterials: Bonding in C materials, Synthesis and properties of fullerene, graphene, and CNT. Diamondoid nanomaterials,, Carbon dots, Pyrolyzed nanocarbon materials. Emerging 2D materials: Transition metal dichalcogenides, Hexagonal Boron nitride, M-Xenes synthesis, properties, and applications.	9

4	Nanomaterials for Energy and Environment: Electrochemical energy storage, hydrogen storage, solar cells, organic solar cells, photocatalysis, water purifications, desalination, solid waste removal Nanobiotechnology: micro and nanofluidics, biochips, lab-on chips and integrated systems. Nanoparticle-based drug delivery,nanostructures in diagnostics Nanocomposites, biodegradable nanocomposites	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand anomalous behavior of material at nanoscale dimensions	**K3**
CO2	Get an introduction to the nanoscale properties of materials	**K3**
CO3	Understand nanomaterial synthesis methods	**K3**
CO4	Explore the properties and application of C-based nanomaterials and other emerging 2D nanomaterials	**K3**
CO5	Get exposure to nanomaterials for energy and nanobiotechnology	**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	-	-	-	-	-	-	-	-	-
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	Introduction to nanoscience and technology	Gabor L Hornyak	CRC Press	2009
2	Fundamentals of nanotechnology	Gabor L Hornyak	CRC press	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to nanotechnology	Charles P Poole, Frank J Owens	Wiley	2003
2	Introduction to nanoscience and nanotechnology	K K Chattopadhyay, A N Banerjee	PHI	2009
3	Basic Principles of Nanotechnology	Wesley C. Sanders	CRC Press	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/118102003
2	https://nptel.ac.in/courses/118102003
3	https://nptel.ac.in/courses/118102003
4	https://onlinecourses.nptel.ac.in/noc23_ge21/preview

SEMESTER S8

AIRCRAFT DESIGN

Course Code	**PEMET865**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	40
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Calculate jet and propeller driven airplane performance(take-off/landing distance, endurance, climb, manoeuvre)
2. Perform conceptual airplane and propulsion sizing estimate to meet specified operational and performance requirements
3. To develop problem solving skills i.e. identifying main issues in aeronautical problems, simplify the problem and solve it using standard tools

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Phases of the design process, conceptual design, preliminary design, detailed design. Typical program organization and personnel responsibilities. Role of aircraft design engineer. Major difference between manned and unmanned air vehicle design.	8
2	Basic aircraft terminology and conventions. Coordinate systems, forces and moments, aerodynamic coefficient. Significance of aerodynamic center. Aircraft weight breakdown and definition. Basic aircraft performance terminology(flight in the horizontal and vertical planes). Aircraft sizing. Factors influencing the aircraft configuration, size, weight. Weight breakdown. Historical weight data. The lift curve and parabolic drag polar.	10

3	Aircraft performance and fuel fraction estimates. Range, Endurance, Manoeuvring flight in the vertical and horizontal planes, Climbing flight, Descend/ Glide, Field Performance- Take-off and Landing. Special performance requirements like accelerated flight.	**8**
4	Propulsion system selection. Flight regimes, Refined performance estimating methods, Installation factors. Configuration trade studies- Configuration types(tailless, canard, conventional), wing location design, Empennage configurations(cruciform, T, H, V, cathedral). Engine placements(single or multi engine). Landing gear type and placement(tail dragger, tricycle, tandem). Airofoil selection,packaging for storage/transport	**10**

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	To make the required decisions during the total design cycle of an aircraft including conceptual, preliminary and detailed design	**K2**
CO2	To distinguish and understand the design phases of an aircraft.	**K2**
CO3	To be able to calculate the performance characteristics of aircraft	**K2**
CO4	To evaluate and understand layout design of different aircrafts	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Aircraft Design: A conceptual Approach	Daniel P. Raymer	AIAA	2012
2	Introduction to Aircraft Design	John P Fielding	Cambridge Aerospace Series	2 2017
3	Aircraft Performance	Martin E. Eshelby	Elsevier	2000

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Aircraft Engineering Design, Structures and Systems	Ian Booth	NY research press	2018

SEMESTER S8

INDUSTRIAL HYDRAULICS AND AUTOMATION

Course Code	**OEMET831**	**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. To know about the basic elements of closed loop hydraulic system
2. To do the sizing and system design of typical hydraulic systems
3. To design and develop low-cost automation circuits for industrial problems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators –election, specification and characteristics	**8**
2	Control and regulation elements: Pressure - direction and flow control valves -relief valves, non-return and safety valves - actuation systems.	**8**
3	Hydraulic system for industrial equipment. e.g. Counter balance circuit, sequencing circuit, the tandem actuator of hydraulic actuators, steering circuit used in automobiles, Hydraulic press circuit operation, closed-circuit and open-circuit hydrostatic transmission, Accumulator circuit for intermittent operation of actuators	**10**
4	Circuits: sequential circuits - cascade methods - mapping methods – step counter method, compound circuit design - combination circuit design. -fault finding of circuits - use of microprocessors for sequencing Introduction to different types of industrial controllers- Types of automation system ,PLC, Low cost automation	**10**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the various components in industrial hydraulic system	**K2**
CO2	Understand the various hydraulic circuits used in industries	**K2**
CO3	To design simple hydraulic circuits	**K3**
CO4	Understand the industrial controllers and automation systems	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	1	1	-	-	-	-	-	-	-
CO2	3	3	-	1	1	-	-	-	-	-	-	-
CO3	3	3	-	1	1	-	-	-	-	-	-	-
CO4	3	3	-	1	1	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Hydraulic and Pneumatics	Andrew Parr	Jaico Publishing House,	1,1999
2	Hydraulic systems: Principles and maintenance	Majumdar, S. R.	. Tata McGraw-Hill Education	1,2013
3	Fluid power circuits and controls: fundamentals and applications.	Cundiff, J. S.	CRC Press.	1,2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Pneumatic systems: Principles and maintenance.	Majumdar, S. R.	. Tata McGraw-Hill Education	1,2010
2	Hydraulic control systems.	Herbert E. Merritt.	John Wiley & Sons.	1,1967
3	Fundamentals of fluid power control	Watton, J	University Press	1,2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_me69/preview
2	https://onlinecourses.nptel.ac.in/noc24_me69/preview
3	https://onlinecourses.nptel.ac.in/noc24_me69/preview
4	https://onlinecourses.nptel.ac.in/noc24_me69/preview

SEMESTER S8

3D PRINTING AND TOOLING

Course Code	**OEMET832**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	**Course Type**	Theory

Course Objectives:

1. To demonstrate appropriate level of understanding on principles of additive manufacturing
2. To understand the different additive manufacturing technologies.
3. To choose appropriate materials for additive manufacturing processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Additive Manufacturing (AM) –**Basic principle of AM-Procedure of product development in AM process chain. Classification of additive manufacturing processes, Basic concept, Digitization techniques, Benefits and challenges in AM. **Data processing for AM-** CAD model preparation, Part orientation and support generation, Slicing methods, Tool path generation, STL Formats. Demonstration of slicing software packages.	**8**
2	**Common AM technologies:** Principle, materials, process parameters, advantages and applications of: Stereo Lithography (SLA), Digital Light Processing (DLP), Continuous Liquid Interface Production (CLIP), Laminated Object Manufacturing (LOM), Ultrasonic AM (UAM), 3D printing, Binder Jetting, Material Jetting, Fused Deposition Modelling (FDM), Direct Ink Writing (DIW).	**10**

3	**Common AM technologies:** Principle, materials, process parameters, advantages and applications of: Selective Laser Sintering (SLS), Selection Laser Melting (SLM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing (WAAM), Laser Engineering Net Shaping (LENS).	**10**
4	**Indirect methods for Rapid Tool Production-** Role of indirect methods in tool production, Metal deposition Tools, RTV Tools, Eoxy Tools, Ceramic Tools, Cast Metal Tools, Investment Casting, Fusible Metallic Core and Sand casting. **Direct Methods for Rapid Tool Production-** Classification of Direct Rapid Tool Methods, Laminated Object Manufactured Tools, Vacuum Forming Tools, Paper Pulp Molding Tools, Framework for Composite Manufacture.	**8**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the development of AM from conventional manufacturing systems.	**K2**
CO2	Understand the data processing techniques in AM process	**K2**
CO3	Understand the principles of AM processes.	**K2**
CO4	Understand the RP tooling applications of AM processes.	**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	-	-	-		-	-	-	-	-	-	-
CO2	2	2	2	-	3	-	-	-	-	-	-	-
CO3	2	-	-	-		-	-	-	-	-	-	-
CO4	2	-	-	-		-	-	-	-	-	-	-
CO5	2	-	-	-		-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing.	Gibson l D. W. Rosen l and B. Stucker	Springer	Second Edition, 2015
2	Rapid prototyping: Principles and applications	Chua, C.K., Leong K.F. and Lim C.S.	World Scientific Publishers	Third edition, 2010.
3	Rapid Manufacturing The Technologies and Applications of Rapid Prototyping and Rapid Tooling	D.T. Pham and S.S. Dimov	Springer London Ltd	Reprint of the original 1st ed. 2001, 2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing: Principles, technologies and Application	C.P. Paul , A.N. Jinoop	McGraw Hill	First Edition, 2021
2	Additive Manufacturing Technologies	S. Shiva, Anuj K. Shukla	Wiley	First Edition, 2024
3	Additive Manufacturing: Fundamentals and Advancements	Manu Srivastava, SandeepRathee, Sachin Maheshwari	CRC Press	First Edition, 2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1,2,3 and 4	NOC: Fundamentals of Additive Manufacturing Technologies, IIT Guwahati by Prof. Sajan Kapil Link: https://nptel.ac.in/courses/112103306

SEMESTER S8

NUMERICAL TECHNIQUES ENGINEERING

Course Code	**OEMET833**	**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. To get an awareness about the usefulness of numerical methods in solving different engineering problems
2. To understand the error involved in numerical analysis

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	Motivation and Applications of numerical methods, Significant digits, Accuracy and precision; Truncation and round-off errors. Roots of nonlinear equations-Bisection method, Newton Raphson method Solution of system of linear equations-Gauss elimination, Gauss Jordan, Gauss Siedel, LU decomposition Curve fitting:Least square regression-Linear regression, linearization of nonlinear relationships, Polynomial and multiple linear regression	**8**
2	Curve fitting: Interpolation-Newton's forward, backward, divided difference, Lagrange's interpolation, cubic spline Numerical differentiation-Difference formula, Newton's forward, backward and divided difference method, Sterling's formula Numerical integration-Trapezoidal, Simpson's one-third rule, Simpson's three-eight rule, Gauss Quadrature	**10**

3	Numerical solution of ordinary differential equations-Initial value and boundary value problems Taylor's method, Euler method, Modified Euler method, Runge Kutta fourth order method for first order, second order and simultaneous first order differential equations, Predictor corrector method, Shooting method, finite difference method	**9**
4	Numerical solution of partial differential equation-Types, Difference equations Elliptic equation-Laplace equation, Poisson's equation, Liebmann's iterative method, Parabolic equation-explicit and implicit method, convergence and stability, Crank Nicolson method, Hyperbolic equation	**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	Apply numerical methods to solve linear and nonlinear equations	**K3**
CO2	Implement numerical schemes to fit data	**K3**
CO3	Solve differentiation and integration numerically	**K3**
CO4	Execute numerical procedures to solve ordinary and partial differential equations	**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	-	-	3	-	-	-	-	-	-	2
CO2	3	2	-	2	3	-	-	-	-	-	-	2
CO3	3	2	-	-	3	-	-	-	-	-	-	2
CO4	3	2	-	-	3	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Numerical methods for Engineers	Steven C Chapra, Reymond P Canale	Mc Graw Hill	6th Edition, 2010
2	Numerical Methods for Engineers	Gupta S.K.	New Age International	1995
3	Numerical methods	E Balagurusamy	Mc Graw Hill Education	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Applied Numerical Analysis	Gerald, C. F. and Wheatly P O	Wesley	6th Edition
2	Numerical Methods for Scientific and Engineering Computation	Jain, M. K., Iyengar, S. R. K. and Jain, R. K.	New Age Pvt. Pub, New Delhi	
3	Elementary Numerical Analysis	Conte, S. D. and De Boor, C.	Mc Graw Hill Publisher	
4	Applied Numerical Analysis	Krishnamurthy, E. V. & Sen, S. K.	East West Publication	
5	An introduction to numerical analysis	Suli & Mayers	Cambridge University Press	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/127/106/127106019/

SEMESTER S8

BUSINESS ORGANIZATION AND DEVELOPMENT

Course Code	OEMET834	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 understand the Business organisation and Enterprises.

2. To acquire knowledge about Development & Establishment of Enterprises

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**INTRODUCTION**:-Business-Concept-Objectives-Characteristics .Business plan- Structure of Business plan-Major Financial decisions in Business-External and Internal factors affecting. Distinction of Business, Commerce and Trade. Industrialization- Globalization and Modern day Business. Need of Business Ethics and Business Responsibility.	9
2	**BUSINESS ORGANIZATIONS:-** Forms of Business Organizations- Sole proprietor – Partnership- Types- One person Company- Joint stock Company- Private & Public limited Companies. Limited liability Partnership (LLP). Co-operative Organizations, Multi National Companies (MNC)**.**Entrepreneurship -Forms of Entrepreneurship -Indian Scenario-Skill India- Make in India-Start up India**.**	9
3	**DEVELOPMENT & ESTABLISHMENT OF BUSINESS:-**Business Formation stages- Promotion- Incorporation and registration -Capital-Sources of Capital-Commencement-Documentation- Memorandum and articles of association-Prospectus. Establishing- Alternative identification -expansion-Market feasibility -Market Assessment-Technology in Business-Financial allocation- HR upgradation.Supporting Organisations-Chamber of Commerce.	9

4	**BUSINESS CHANNELS** : - Distribution Channels- Functions- Types- Internal and external trades. Import and export.Whole sale and retail system. Theory of retailing. Business channel Intermediaries. Franchising – Branding. Business Insurance system. Business Combination systems- Needs- Acquisition-Merging- Takeover.	9

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of Business organisation.	**K1**
CO2	To acquire the knowledge on distinction of different organisations.	**K2**
CO3	To familiarize the stages of development and establishment of Business.	**K2**
CO4	To identify different Business channels	**K1**

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	-	-	-	-	-	1	-	1	-	-	1
CO2	2	1	-	-	-	1	-	-	-	-	-	1
CO3	1	1	-	-	1	-	-	-	-	-	1	1
CO4	1	1	-	-	-	1	-	-	-	-	-	1

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Business Organisation & Management	T.N Chhabra	Sun India	2021
2	Modern Business Organisation & Management	S. A Sherlekar	Himalaya publishing	2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Business Organisation and Management	Basu C R	Tata McGraw-Hill	2017
2	Essentials of Management	Singh B P & Singh A K	Excel Books	2002
3	Business Organisation& Management	Vasishth N&Rajput N	Kitab Mahal	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/107/110101146/
2	https://archive.nptel.ac.in/courses/110/107/110101146/
3	https://archive.nptel.ac.in/courses/110/107/110101146/
4	https://archive.nptel.ac.in/courses/110/107/110101146/

SEMESTER S8

WORLD CLASS MANUFACTURING

Course Code	**OEMET835**	**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)	GCPHT121	**Course Type**	Theory

Course Objectives:

1. Understand the Industrial practices adopted in World class manufacturing.
2. To familiarise the strategic planning for WCM.
3. To familiarise WCM tools.
4. Acquire the knowledge about Recent trends in WCM

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**INTRODUCTION:** World class manufacturing-Definition-Historic Journey- Five levels led to WCM -characteristics of WCM-Pillars of WCM-Control Techniques of World class Manufactures- Principles of WCM- JIT-Zero waste Concept- TQM- TPM.	9
2	**PLANNING& HRD PRACTICES IN WCM:** Manufacturing strategy – Strategy Procedure- Types of strategy -Competitive priorities-Aggregate planning-Master Production schedule. Employee Morale-Team work- Employee Involvement-Cross functional teams-Motivation &Appraisal. Work study methods	9
3	**WCM CONCEPTS & TOOLS :** concepts –AMBITE- MRP II-TOPP-Automation systems- Types-Modern Manufacturing systems- Flexible Manufacturing- Lean Mnufacturing-5S-Agile Manufacturing Six Sigma-Automated Material Handling systems. Process Design & Process design tools. Bar code systems. IOT in manufacturing.	9
4	**WORLD CLASS MANUFACTURING -RECENT TRENDS &INDIA**: World class manufacturing Companies in INDIA-Production 4.0-Industry 4.0-Digitalization process in India-AI-Robotics-3D Printing-Extended Realities- VR& AR –Digital Twins .Automation in Industries-Case studies. Reshoring-Make in INDIA-Sustainable Manufacturing.	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	To familiarise with the basic concepts in World class Manufacturing.	**K1**
CO2	To understand the Strategy planning in WCM	**K1**
CO3	To Identify the employee involvement in WCM	**K1**
CO4	To Examine & Categorize different tools in WCM	**K2**
CO5	Learn different concepts in Modern day Manufacturing	**K1**
CO6	Analyse Indian scenario & WCM	**K2**
CO7	Identify various modern day trends and terminologies in WCM	**K1**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1						1		1			1
CO2	2	1				1						1
CO3	1							1	1			1
CO4	2	1			1	1	1	1				1
CO5	1	1				1						1
CO6	1						1				1	2
CO7	1				1			1				1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	World class Manufacturing, The lessons of simplicity applied.	Richard J Schonberger	The FREE PRESS	(2013)
2	World class Manufacturing	B.S. Sahay, K B C Saxena, Ashish Kumar	Infinity Publishers	Ist Edition (2018)
3	Strategic Decision making in Modern Manufacturing	Harinder Sing Jagdev,Attracta Brennan,J.Browne	Springer	Reprint Edition (2013)

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	World class Manufacturing	Adeel Hejaji	Lambert	2015
2	World class Manufacturing and Material Handling	Edward H Frazelle	Mc GrawHill	2nd Edition 2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/107/110107116/
2	https://archive.nptel.ac.in/courses/110/107/110107116/
3	https://archive.nptel.ac.in/courses/110/107/110107116/
4	https://archive.nptel.ac.in/courses/110/107/110107116/

SEMESTER S8

MICRO ELECTRO MECHANICAL SYSTEMS

Course Code	**OEMET836**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To Understand micro electromechanical systems and components
2. To understand the science of microsystems design in detail
3. To understand MEMS Fabrication technologies and the importance of CAD in MEMS Fabrication

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Definition of MEMS. MEMS devices. Silicon as a MEMS material – mechanical properties of silicon. Mechanical components in MEMS. Design concepts of mechanical components. Working Principles of Microsystems.	9
2	Engineering Science for Microsystems design and Fabrication. Scaling laws – Scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity-fluid mechanics and heat transfer	9
3	Materials for MEMS and Microsystems. Fabrication technologies – Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapour Deposition – Etching. Micro manufacturing – Bulk and surface micro machining – LIGA	9
4	Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly – Selection of Packaging Materials.	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand micro electromechanical systems, MEMS components, MEMS design concepts and working principles.	**K2**
CO2	Understand the engineering and physics of MEMS Fabrication Process	**K2**
CO3	Understand the various processes in MEMS Fabrication	**K2**
CO4	Understand the interface between MEMS and CAD	**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	-	-	-	-	-
CO3	3	-	-	-	-	-	-	-	-	-	-	-
CO4	3	-	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	Mems & Microsystems Design and Manufacturing	Tai–Ran Hsu	John Wiley & Sons	2008 2nd Edition

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of Microfabrication	Marc J Madou	CRC Press	2002 2nd Edition
2	The MEMS Handbook	Mohamed Gad-el-Hak	CRC Press	2002

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
1-2	https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=16&lesson=17 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=16&lesson=18 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=16&lesson=19
3-4	https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=23 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=24 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=25 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=26 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=27 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=30&lesson=33

SEMESTER S8

PRODUCT DESIGN AND INNOVATION

Course Code	**PEMET837**	**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 create confidence in developing new products.
2. To acquaint with methods and tools for product design and development.
3. To equip with practical knowledge in conceptualization, design and development of new product

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction: Classification/ Specifications of Products, Product life cycle, product mix. Introduction to product design, Modern product development process Design by evolution, Design by innovation, Morphology of design Ethics in product design, legal factors and social issues	9
2	Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design. Conceptual Design: Generation, selection & embodiment of concept, Product architecture. Industrial design: process, need. Robust Design: Taguchi Designs, Design of experiments	9
3	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly. Design for Maintenance. Design for Environment. Ergonomics in product design. Aesthetics in product design. Concepts of size and texture colour. Value Engineering - Definition. Methodology, Case studies.	9

4	Product costing. Economic analysis: Qualitative & Quantitative. Psychological and Physiological considerations Concurrent Engineering - Elements of concurrent engineering, Benefits Rapid prototyping: concepts, processes and advantages. Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering. Tools for product design – Drafting / Modelling software. Patents & IP Acts- Overview, Disclosure preparation	**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	Determine the life cycle of a product and product development process	**K2**
CO2	Develop knowledge of robust design and conceptual design	**K2**
CO3	Introduce the concept of Design for Manufacturing and Assembly in product design	**K2**
CO4	Use value engineering in the development of product	**K2**
CO5	Incorporate ergonomics and rapid prototyping in product development	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-
CO5	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Product Design & Development.	Karl T Ulrich, Steven D Eppinger	Tata McGraw Hill	2003

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Product Design: “Techniques in Reverse Engineering and new Product Development.”,	Kevin Otto & Kristin Wood	Pearson Education New Delhi	2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/107/103/107103082/