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 2nd 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	1st Edition, 2011
4	Embedded Systems: An Integrated Approach	Lyla B Das	Pearson Education India	1st 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	3rd 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	5th, 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	ThirdEditio n,2009
2	Advanced Mechanicsof Solids	LSSrinath	Tata McGraw Hill Publishing Company,	ThirdEditio n,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	FirstEditio n.2018
3	Elasticity:Theory, Applications and Numerics	SaddM. H.	AcademicPress	SecondEdit ion,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**

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CO1	3			1								
CO2	3			3								
CO3	3			2	3							
CO4	3			1								
CO5	3			1								

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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

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5. **Record (5 Marks)**

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