DEPARTMENT OF MECHANICAL ENGINEERING
GURU JAMBHESHWAR UNIVERSITY OF SCIENCE & TECHNOLOGY, HISAR

B.Tech. (Mechanical Engineering) Programme

VIII- Semester

Sr. No.	Category	Course Code		Course Title	Hours per week			Course Credits		
		Theory	Practical		L	T	P	Theory	Practical	Total
1.	Professional Elective Courses	PEC (refer to list)****	--	Professional Elective -IV	3	0	0	3.0	--	3.0
2.	Professional Elective Courses	PEC (refer to list)*****	--	Professional Elective -V	3	0	0	3.0	--	3.0
3.	Professional Core Courses	PCC-ME402-T	--	Mechanical Vibrations	3	0	0	3.0	--	3.0
4.	Professional Core Courses	PCC-ME403-T	PCC-ME403-P	Computer Aided Design and Manufacturing	3	0	2	3.0	1.0	4.0
5.	Project Work, Seminar and Internship in Industry	--	PROJ-ME403-P	Major Project	0	0	10	--	5.0	5.0
6.	Project Work, Seminar and Internship in Industry	--	PROJ-ME404-P	Seminar	0	0	2	--	1.0	1.0
					12	0	14			
Total credits										19.0

****Professional Elective -IV	
Course Code	**Course Name**
PEC-ME459-T	Robotics
PEC-ME460-T	Mechatronics
PEC-ME461-T	Automatic Control
PEC-ME462-T	Flexible Manufacturing Systems
PEC-ME463-T	Rapid Prototyping

*****Professional Elective -V	
Course Code	**Course Name**
PEC-ME464-T	Power Plant Engineering
PEC-ME465-T	Solar Energy Engineering
PEC-ME466-T	Design of Heat Exchangers
PEC-ME467-T	Turbo Machinery
PEC-ME468-T	Computational Fluid Dynamics

<u>8th Semester</u>

MECHANICAL VIBRATIONS (THEORY)

General Course Information

Course Code: PEC-ME402-T Course Category: Professional Core Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Student will be able to understand the fundamentals, principle and cause of mechanical vibrations.	L1
CO2	Student will be able to understand the various methods of solving vibration problems and apply them to vibration problems.	L2
CO3	Student will be able to analyse and solve single, two and multi degree of freedom practical vibration problems.	L3
CO4	Student will be able to analyse and solve free and forced mechanical vibration problems.	L4
CO5	Student will be able to understand and apply Numerical Methods to solve multi DOF vibration problems.	L5

Course Contents

UNIT-I

Free and Damped Vibrations : Importance of Study of Vibrations, Classifications of Vibrations, Free and Forced, Undamped and Damped, Linear and Non-linear, Deterministic and Random, Harmonic Motion, Vector and Complex Number Representations, Definitions and Terminology, Periodic Functions, Harmonic Analysis, Fourier Series Expansion. Single Degree of Freedom system, D'Alemberts Principle, Energy Methods, Rayleighs Method, Application of these Methods, Damped Free Vibrations, Logarithmic Decrement, Under Damping, Critical and Over Damping, Coulomb Damping.

UNIT-II

Harmonically Excited Vibrations : Forced Damped Harmonic Vibration of Single Degree of Freedom Systems, Rotating Unbalance, Rotor Unbalance, Critical Speeds and Whirling of Rotating Shafts, SupportMotion, Vibration Isolation, Energy Dissipated by Damping, Equivalent, Viscous Camping, Structural Damping Sharpness of Resonance, Vibration Measuring Instruments.

UNIT-III

Two Degrees of Freedom Systems: Introduction to Multi-Degree of Freedom Systems, Normal Mode Vibrations, Coordinate Coupling, Principal Coordinates, Free Vibrations in Terms of Initial Conditions, Forced Harmonic Vibrations, Vibration Absorber, Centrifugal Vibration Absorber, Vibration Damper. Normal Mode Vibration of

Continuous System**:** Vibrating String, Longitudinal Vibrations of Rod, Torsional Vibrations of Rod, and Lateral Vibrations of Beam.

UNIT-IV

Multi degrees of Freedom Systems and Numerical Methods: Introduction, Influence Coefficients, Stiffness Matrix, Flexibility Matrix, Natural Frequencies and Normal Modes, Orthogonality of Normal Modes, Dunkerley's Equation, Method of Matrix Iteration, The Holzer Type Problem, Geared and Branched Systems, Beams.

Text and Reference Books

1. Mechanical vibrations: J.S. Mehta & A.S. Kailey, S.Chand.
2. Mechanical vibrations: V.P. Singh, Dhanpat Rai & Co.
3. Theory of Vibrations with Applications W.T. Thomson, Prentice Hall of India.
4. Mechanical Vibration: G.K. Grover and S.P. Nigam, Nem Chand and Sons.
5. Theory and Practice of Mechanical Vibrations J.S. Rao and K. Gupta, Wiley Eastern Ltd.
6. Mechanical Vibrations S.S. Rao, Addison – Wesely Publishing Company

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	1	1	1	1	1	1	1	3	3	2
CO2	3	3	1	2	1	1	1	1	1	1	1	1	3	3	2
CO3	3	3	3	2	1	1	1	1	1	1	1	1	3	3	2
CO4	3	3	1	2	1	1	1	1	1	1	1	1	3	3	2
CO5	3	3	1	2	1	1	1	1	1	1	1	1	3	3	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

COMPUTER AIDED DESIGN AND MANUFACTURING (THEORY)

General Course Information

Course Code: PEC-ME403-T Course Category: Professional Core Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Student will be able to define the scope and applications of CAD/CAM and geometric modeling techniques.	L1
CO2	Student will be able to understand the basic overview of geometric transformations, curves, surface and solids.	L2
CO3	Student will be able to use computer assisted part programming for CNC machines	L3
CO4	Student will be able to generate CNC part programmes	L4

Course Contents

UNIT-I

Introduction to CAD/CAM: Historical developments, product life cycle, CAD/CAM systems, scope of CAD/CAM, CAD/CAM applications, 3D modeling approaches, types of geometric modeling, coordinate systems, sketching and sketch planes, basic features of a CAD/CAM system (extrusion, revolution, hole, cut, sweep, loft, fillet, chamfer, rib, shell, draft, patterns spiral and helix), feature based modeling, parametric modeling, datum features, geometric constraints, modeling operations, heterogeneous modeling, modeling strategies, master model, system modes, model viewing .

UNIT-II

Transformations: Introduction, transformation of points and line, 2-D translation, rotation, reflection, scaling, homogeneous representation, concatenated transformation, mapping of geometric models, 3-D scaling, shearing, rotation, reflection and translation, combined transformations, orthographic, Isometric and perspective projections.

Curves: Algebraic and geometric forms, tangents and normal, blending functions re-parameterization, straight lines, conics, cubic Splines, Bezier curves and B-Spline curves.

UNIT-III

Surfaces: Algebraic and geometric forms, tangents and normal, blending functions, re-parameterization, sixteen point form, four curve form, plane surface, ruled surface, surface of revolution, tabulated cylinder, bi-cubic surface, Bezier surface, B-Spline surface, surface manipulations.

Solids: Geometry and topology, Solid models and representation schemes, boundary representation, constructive solid geometry, sweep representation, cell decomposition, spatial occupancy enumeration, solid manipulators.

UNIT-IV

CNC Technology: Introduction, types of NC systems, NC machine tools, principle of operation of CNC, advantages and limitations of CNC systems, Direct numerical control (DNC) and its application, MCU and other components.

Part Programming: Integrating CAD, NC and CAM, preparing CAD data for NC system, NC part programming, coordinate systems, NC programming languages, G & M codes, Part program for simple parts, CNC part programming, axes of CNC machines, computer aided part programming using APT, Automatic NC program generation from CAD models.

Text and Reference Books

1. Zeid, I., “CAD/CAM”, McGraw Hill, 2008.
2. Groover and Zimmer, “CAD/ CAM”, Prantice Hall.
3. Rogers, D. F. and Adams, J. A., “Mathematical Elements for Computer Graphics”, McGraw Hill.
4. Radhakrishnan, P. and Kothandaraman, C. P., “Computer Graphics & Design”, Dhanpat Rai Publication”, 2nd edition, 2005.
5. Krishnamoorathy, C. S. and Rajeev, J. S., “Computer Aided Design (Software and Analysis Tools)”, Narosa Publication House, 2nd edition, 2005.
6. Kundra T. K., Rao P. N. and Tiwari N. K, “Numerical Control and Computer Aided Manufacturing”, McGraw Hill.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	--	1	1	1	--	--	--	2	--	3	3	2	2
CO2	3	2	2	2	2	1	--	--	--	2	--	3	3	3	2
CO3	3	2	2	3	2	1	--	--	2	2	--	3	3	3	2
CO4	3	2	2	3	3	2	--	--	2	2	--	3	3	3	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

COMPUTER AIDED DESIGN AND MANUFACTURING (LAB)

General Course Information

Course Code: PCC-ME403-P Course Category: Professional Core Course Course Credits: 1.0 Mode: Practical Contact Hours: 02 hours per week	**Course Assessment Methods (internal: 30; external: 70):** Internal practical evaluation is to be done by the course coordinator. The end semester practical examination will be conducted jointly by external and internal examiners.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to draw part drawings and three-dimensional models using CAD techniques.	L1
CO2	Students will be able to generate part programs for industrial components using CAM techniques	L2
CO3	Students will be able to demonstrate working of CNC machines	L3
CO4	Students will be able to examine the industrial drawings and manufactured parts.	L4
CO5	Students will be able to create a product from conceptualization to reality.	L5

Lab Contents

1. To prepare part drawing on CAD softwares (Auotcad, Draftsight etc.)
2. To perform parametric modelling on CAD softwares (Creo/Solid Works/Catia/Inventor etc.).
3. To understand CNC codes and their syntax in respect of CNC Turning Center, CNC Machining Center, and CNC Wire Cut EDM.
4. To perform component identification and work setting of CNC Turning Center.
5. To perform component identification and work setting of CNC Machining Center.
6. To perform component identification and work setting of CNC Wire Cut EDM.
7. To prepare part program for CNC Turning center using CAM software (Cam Concept, Fusion 360, Master Cam etc.)
8. To prepare part program for CNC Machining center using CAM software (Cam Concept, Fusion 360, Master Cam etc.)
9. To prepare part program for CNC Wire Cut EDM using CAM software (Elcam etc.)
10. To machine an industrial part using CNC Turning Center.
11. To machine an industrial part using CNC Machining Center.
12. To machine an industrial part using CNC Wire Cut EDM.

NOTE: *The list is indicative. The teacher can alter/add more number of experiments as per the requirement.*

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	1	1	1	2	2	1	3	3	3	1
CO2	3	3	3	2	2	1	1	1	2	2	1	3	3	3	1
CO3	3	3	3	2	2	1	1	1	2	2	1	3	3	3	1
CO4	3	3	3	2	2	1	1	1	2	2	1	3	3	3	1
CO5	3	3	3	2	2	1	1	1	2	2	1	3	3	3	1

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

MAJOR PROJECT

General Course Information

Course Code: PROJ-ME403-P Course Category: Project work, Seminar and Internship in Industry Course Credits: 5.0 Mode: Practical Contact Hours: 10 hours per week	**Course Assessment Methods (internal: 30; external: 70):** Internal practical evaluation is to be done by the course coordinator. The end semester practical examination will be conducted jointly by external and internal examiners.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to relate the theoretical studies that they learned in the preceding semesters with practical concepts.	L1
CO2	Students will be able to recognise their skill for the solution of identified problem and to develop a prototype mechanical system.	L2
CO3	Students will be able to apply the analytical and design procedures to synthesize a working prototype of a functional mechanical system.	L3
CO4	Students will be able to examine the conditions faced by an engineer starting from the development / modification of an existing functional mechanical system.	L4
CO5	Students will be able to appraise the necessity of project management, teamwork, time management, system integration skills and other related human factors involved in the design and development cycle of an engineering system.	L5

Course Content

Project involving design/ fabrication/ testing computer simulation/ case studies etc. which is commenced in VIIth Semester, will be completed in VIIIth Semester. The student will be required to demonstrate his ideas/design/development in front of the committee constitute of a project coordinator, project guide and senior teachers of the department.
The student will be required to submit three copies of his/her project report to the office of the concerned department for record (one copy each for the deptt. Office, Project guide and University/College library).

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	2	1	2	3	3	3	3	3	3	3
CO2	3	3	3	3	2	2	1	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	1	2	3	3	3	3	3	3	3
CO4	3	3	3	3	2	3	1	2	3	3	3	3	3	3	3
CO5	3	3	3	2	2	3	1	2	3	3	3	3	3	3	3

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

SEMINAR

General Course Information

Course Code: PROJ-ME404-P Course Category: Project work, Seminar and Internship in Industry Course Credits: 1.0 Mode: Practical Contact Hours: 02 hours per week	**Course Assessment Methods (internal: 30; external: 70):** Internal practical evaluation is to be done by the course coordinator. The end semester practical examination will be conducted jointly by external and internal examiners.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to learn recent trends and technologies in the field of Mechanical Engineering	L1
CO2	Students will be able to recognizing problems after doing research literature survey using various resources	L2
CO3	Students will be able to prepare concise, comprehend and conclude selective topic in the field of Mechanical Engineering	L3
CO4	Students will be able to develop skills in presentation and discussion of research topics in a public forum	L4

Course Content

The students are required to give power point presentation on the topic related to current research area in the field of Mechanical Engineering. The students are also required to submit a detailed report on the topic of seminar. The presentation should be held in the class room/ seminar hall in presence of the course coordinator.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	--	--	--	--	--	2	2	3	--	2
CO2	3	1	2	2	--	--	--	--	--	2	--	2	2	--	2
CO3	--	--	--	--	--	--	--	--	--	3	--	2	--	--	--
CO4	3	2	2	2	--	--	--	--	--	3		2	2	2	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

Professional Elective -IV

Course Code	Course Name	L	T	P	Credits
PEC-ME459-T	Robotics	3	-	-	3.0
PEC-ME460-T	Mechatronics	3	-	-	3.0
PEC-ME461-T	Automatic Control	3	-	-	3.0
PEC-ME462-T	Flexible Manufacturing Systems	3	-	-	3.0
PEC-ME463-T	Rapid Prototyping	3	-	-	3.0

ROBOTICS (THEORY)

General Course Information

Course Code: PEC-ME459-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks.For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to learn standard terminologies, applications, design specifications, and mechanical design aspects both kinematics, Trajectory planning, work cell control and dynamics of industrial robotic manipulators.	L1
CO2	Students will be able to understand the robot kinematics and trajectory planning	L2
CO3	Students will be able to apply the concepts of robotic workspace analysis for design of robotic manipulator for required work cell applications	L3
CO4	Students will be able to develop the algorithms for design of robotic work cell controller and its programming for given serial robotic manipulator	L4

Course Content

UNIT-I

Robotic Manipulation: Automation and Robots; Robot Classification – Drive Technologies, Work-Envelope Geometries, Motion Control Methods, Applications; Robot Specifications – No. of Axes, Capacity and Speed, Reach and Stroke, Tool Orientation, Repeatability, Precision, Accuracy, Operating Environment, An Example; Rhino X-3.

Direct Kinematics: The Arm Equation Homogenous Co-ordinates – Frames, Translations and Rotations, Composite Homogenous Transformations; Screw Transformations; Link Co-ordinates; The Arm Equation; A Five-Axis Articulated Robot; A Four-Axis SCARA Robot; A Six-Axis Articulated Robot; Problems.

UNIT-II

Inverse Kinematics: Solving the Arm Equation: The Inverse Kinematics Problem; General Properties of Solutions; Tool Configuration; Inverse Kinematics of a Five-Axis Articulated Robot, Four-Axis SCARA Robot, Six-Axis Articulated Robot and Three-Axis Planer Articulated Robot; A Robotic Work Cell; Problems.

Work Space Analysis and Trajectory Planning: Work Space Analysis; Work Envelope of a Five-Axis Articulated Robot; Work Envelope of a Four Axis SCARA Robot; Work Space Fixtures; The Pick and Place Operation; Continuous Path Motion; Interpolated Motion; Straight Line Motion; Problems.

UNIT-III

Differential Motion and Statics: The Tool Configuration Jacobian Matrix; Joint – Space Singularities; Generalised Inverses; Resolved – Motion Rate Control; n > 6; Rate Control of Redundant Reboots : n > 6; Rate Control using (1) – Inverses; The Manipulator Jacobian; Induced Joint Torques and Forces; Problems.

Manipulator Dynamics: Lagrange's Equation; Kinetic & Potential Energy; Generalised Force; Lagrange – Euler Dynamic Model; Dynamic Models of a Two-Axis Planer Articulated Robot and A Three-Axis SCARA Robot; Direct & Inverse Dynamics; Recursive Newton - Euler Formulation; Dynamic Model of a One-Axis Robot; Problems.

UNIT-IV

Robot Control: The Control Problems; State Equations; Constant Solutions; Linear Feedback Systems; Single-Axis PID Control; PD-Gravity Control; Computed –Torque Control; Variable-structure Control; Impedance Control; Problems.

Methods of Robot Programming: Robot programming methods, introduction to basic robot programming languages, and various on-line and off-line robot programming methods.

Text and Reference Books

1. Fundamental of Robotics (Analysis &Control) by Robert J. Schilling, Published by PHI, Pvt. Ltd., New Delhi.
2. Introduction to Robotics (Mechanics & Control) by John J. Craig, Published by Addition Wesley (Intl. Student Edition).
3. Analysical Robotics & Mechatronics by Wolfram Stadler, Published by Mc-Graw Hill, Inc., New Delhi.
4. Industrial Robotics - Technology, Programming &Applications byMikell P. Grover, Weiss, Nagel and Ordef, Published by Mc-Graw Hill International Edition.
5. A Robot Engg. Test Book - Mohsen Shahinpoor, Harper & Low, Publishing New York.
6. Robotic Engineering – An Integrated Approach: Richard D.Klafter, Thomas A. Chmielewski and Michael Negin PHI 1989.
7. Foundations of Robotics Analysis and Control - Tsuneo Yashikawa MIT Press 1990, Indian Reprint 1998.
8. Robots and Control - R.K.Mittal and I.J.Nagrath - Tata McGraw Hill 2003.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	--	--	--	--	--	2	--	2	3	2	2
CO2	3	1	2	2	2	--	--	--	--	2	--	2	2	2	2
CO3	2	2	2	2	3	--	--	2	--	3	--	2	3	2	2
CO4	3	2	2	2	3	--	--	2	--	3	--	2	2	2	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

MECHATRONICS (THEORY)

General Course Information

Course Code: PEC-ME460-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to construct the block diagram of any physical Mechatronics device used in day-to-day life	L1
CO2	Students will be able to calculate the output to input relation of any physical model in the form of a transfer function	L2
CO3	Students will be able to evaluate the performance of any physical system in terms of its performance parameters.	L3
CO4	Students will be able to develop the mathematical model of any physical model from any engineering domain	L4
CO5	Students will be able to recognize the key features of different type of controllers and develop a suitable controller to obtain the desired performance from the system.	L5

Course Content

UNIT-I

Introduction and Basics: Mechatronics, Measurement System with its constituent elements; Open and Closed Loop Systems; Sequential Controllers; Micro-processor Based Controllers; The Mechatronics Approach.

Hardware of Measurement Systems: A review of Displacement, Position Velocity, Motion, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature, Light Sensors / alongwith Performance Terminology; Selection of Sensors; Input Data by Switches; Signal Conditioning; Brief Review of Operational Amplifier; Protection; Fitering; Wheat Stone Bridge; Digital Signals; Multiplexers; Data Acqusition; Digital Signal Processing; Pulse Modulation; Data Presentation Systems – Displays; Data Presentation Elements; Magnetic Recording; Data Acquisition Systems; Testing & Calibration; Problems.

UNIT-II

Pneumatic, Hydraulic, Mechanical and Electrical Actuation Systems: Pneumatic and Hydraulic Systems; Directional Control Valves; Valve Symbols; Pressure Control Valves; Cylinder Sequencing; Process Control Valves; Rotary Actuators; Mechanical Systems – Types of Motion, Kinematic Chains, Cams, Gear Trains, Ratchet & Pawl, Belt & Chain Drives, Bearings, Mechanical Aspect of Motor Selection; Electrical Systems; Mechanical & Solid State Switches; Solenoids; D.C. & A.C. Motors; Stepper Motors; Problems.

System Modeling and Performance: Engg. Systems; Rotational – Translational Systems; Electro-mechanical Systems; Hydraulic – Mechanical Systems; A review of modeling of First and Second Order Systems and

Performance Measures; Transfer Functions for first order System, Second Order System, Systems in series & Systems with Feedback Loops; Frequency Response of First Order and Second Order Systems; Bode Plots: Performance Specifications: Stability; Problems.

UNIT-III

Closed Loop Controllers: Continuous and Discrete Processes – Lag, Steady State Error; Control Modes; Two- step Mode; Proportional Mode – Electronic Proportional Controllers; Derivative Control – Proportional plus Derivative Control; Integral Control - Proportional plus Integral Control; PID Controller – Operational Amplifier PID Circuits; Digital Controllers – Implementing Control Modes; Control System Performance; Controller Tuning – Process Reaction Method & Ultimate Cycle Method; Velocity Control; Adaptative Control; Problems.

Digital Logic and Programmable Logic Controllers: A Review of Number Systems & Logic Gates; Boolean Algebra; Kanaugh Maps; Sequential Logic; Basic Structure of Programmable Logic Controllers; Input/ Output Processing; Programming; Timers, Internal Relays and Counters; Master & Jump Controls; Data Handling; Analogue Input/ Output; Selection of a PLC; Problems.

UNIT-IV

Microprocessors and Input/Output Systems: Control; Microcomputer Structure; Micro- controllers; Applications; Programming Languages; Instruction Sets; Assembly Language Programs; Subroutines; Why C Language ? A review of Program Structure, Branches, Loops, Arrays, Pointer; Examples of Programs; Interfacing; Input/ Output; Interface Requirements; Peripheral Interface Adaptors; Serial Communication Interface; Examples of Interfacing; Problems.

Design and Mechatronics: Design Process; Traditional and Mechatronics Design; Possible Mechatronics design solutions for Timed Switch, Wind Screen Wiper Motion, Bath Room Scale, A Pick & Place Robot, Automatic Camera, Engine Management System & Bar Code Recorder.

Text and Reference Books

1. Mechatronics by W. Bolton, Published by Addition Wesley.
2. Mechatronics System Design – Devdas Shetty and Richard A. Kolx Brooks/ Cole.
3. Introduction to Mechatronics and Measuring System: david G. Alciation and Michael B. Hist and Tata McGraw Hill.
4. Mechtronics – Sensing to Implementation - C.R.Venkataraman, Sapna .

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	2	--	--	1	2	2	3	3	2	2
CO2	3	1	2	2	2	2	--	--	2	2	2	3	3	2	2
CO3	3	2	3	3	2	2	--	--	2	3	2	3	3	2	3
CO4	3	2	2	2	3	2	--	--	1	3	2	3	3	2	2
CO5	3	2	3	3	2	2	--	--	2	3	2	3	3	2	3

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

AUTOMATIC CONTROL (THEORY)

General Course Information

Course Code: PEC-ME461-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to describe the control system, controller and applications of control systems	L1
CO2	Students will be able to understand response analysis and stability criteria of control system.	L2
CO3	Students will be able to integrate mechanical, electronics, instrumentation, computer and controls fields.	L3
CO4	Students will be able to evaluate the performance of control system	L4

Course Content

UNIT-I

Introduction: Types of control systems; Typical Block Diagram: Performance Analysis; Representation of Processes & Control Elements – Mathematical Modeling. Block Diagram Representation, Representation of Systems or Processes, Comparison Elements; Representation of Feedback Control systems – Block Diagram & Transfer Function Representation, Representation of a Temperature Control System, Signal Flow Graphs, Problems.

Types of Controllers: Introduction: Types of Control Action; Hydraulic Controllers; Electronic Controllers; Pneumatic Controllers; Problems.

UNIT-II

Transient And Steady State Response: Time Domain Representation; Laplace Transform Representation; System with Proportional Control; Proportional–cum–Derivative control; Proportional–cum–Integral Control; Error Constants; Problems.

Frequency Response Analysis: Introduction; Closed and Open Loop Transfer Function; Polar Plots; Rectangular Plots; Nichols Plots: Equivalent Unity Feed Back Systems; Problems.

UNIT-III

Stability of Control Systems: Introduction; Characteristic Equation; Routh’s Criterion; Nyquists Criterion, Gain & Phase Margins: Problems.

Root Locus Method: Introduction; Root Ioci of a Second Order System; General Case; Rules for Drawing Forms of Root Ioci; Relation between Root Locus Locations and Transient Response; Parametric Variation; Problems.

UNIT-IV

State Space Analysis of Control Systems: Introduction; Generalized State Equation; Techniques for Deriving System State – Space Equations; Transfer Function from State Equations; Solution of State Vector Differential Equations; Discrete Systems; Problems.

Applications of automatic control – Machine Tool Control, Boiler Control, Engine Governing, Aerospace Control, Active Vibration Control and other control systems

Text and Reference Books

1. Theory & Applications of Automatic Controls by B.C. Nakra, Published by New Age International Pvt. Ltd. Publishers, 2014, New Delhi.
2. Modern Control Engg. by Ugata, Prentice Hall of India, 2012, New Delhi.
3. Automatic Control Systems by Kuo' Published by Prentice Hall of India, 2007, New Delhi.
4. Control System Engineering, I. J. Nagrath and M. Gopal, New Age International Pvt. Ltd. Publishers, 2012, New Delhi.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	2	--	2	--	--	--	1	2	3	3	3	1
CO2	3	2	2	2	2	2	--	--	--	1	2	2	1	3	2
CO3	3	2	2	1	2	3	1	1	3	2	2	2	2	3	2
CO4	2	1	1	--	3	3	1	--	2	2	2	2	1	1	1

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

FLEXIBLE MAUFACTURING SYSTEM (THEORY)

General Course Information

Course Code: PEC-ME462-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to recall basic automation, types of automation and transfer mechanism	L1
CO2	Students will be able to classify different automated assembly systems, quantitative and operational analysis of assembly machine.	L2
CO3	Students will be able to apply the technology, optimum machine arrangement & benefits of group technology.	L3
CO4	Students will be able to examine robotics, material handling, computer-controlled system with their application & benefits.	L4
CO5	Students will be able to formulate a flexible manufacturing systems.	L5

Course Content

UNIT-I

Automation: Types of automation, reasons for automating, automation strategies, Detroit-type automation: Automated flow lines, methods of work part transport, Transfer mechanisms, buffer storage, automation for machining operations.

Automated assembly systems: Design for automated assembly, types of automated assembly systems, part feeding devices, quantitative analysis of the delivery system operation, analysis of a single-station assembly machine, numericals.

UNIT-II

Group Technology: Part families, parts classification and coding, types of classification and coding systems. Machine cell design: The composite part concept, types of cell designs, determining the best machine arrangement, benefits of group technology.

Flexible Manufacturing Systems: Components of an FMS, types of systems, where to apply FMS technology, FMS work stations. Material handling and storage system: Functions of the handling system, FMS layout configurations. Material handling equipment. Computer control system: Computer function, FMS data file, system reports. Planning the FMS, analysis methods for FMS, applications and benefits.

UNIT-III

Robotic technology: Joints and links, common robot configurations, work volume, types of robot control, accuracy and repeatability, other specifications, end effectors, sensors in robotics.

UNIT-IV

Robot programming: Types of programming, lead through programming, motion Programming, interlocks, advantages and disadvantages. Robot languages: Motion programming, simulation and off-line programming, work cell control.

Robot applications: Characteristics of robot applications, robot cell design, types of robot applications: Material handling, processing operations, assembly and inspection.

Text and Reference Books:

1. Automation, Production Systems and Computer Integrated Manufacturing. Groover M.P, Prentice Hall of India.
2. CAD/CAM – Groover M.P, Zimmers E.W, Prentice Hall of India..
3. Approach to Computer Integrated Design and Manufacturing Nanua Singh, John Wiley and Sons, 1998.
4. Production Management Systems: A CIM Perspective Browne J, Harhen J, Shivnan J, Addison Wesley, 2nd Ed. 1996.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	--	1	1	1	2	1	2	3	3	3	2
CO2	3	3	3	2	--	1	1	1	2	1	2	3	3	3	3
CO3	3	3	3	2	--	1	1	1	2	1	2	3	3	3	2
CO4	3	3	3	2	--	1	1	1	2	1	2	3	3	3	2
CO5	3	3	3	2	--	1	1	1	2	1	2	3	3	3	3

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

RAPID PROTOTYPING (THEORY)

General Course Information

Course Code: PEC-ME463-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to learn need & development, benefits and applications of Rapid Prototyping systems.	L1
CO2	Students will be able to understand different types of Rapid Prototyping processes like 3D printing, Stereolithography, Selective Laser Sintering, Laminated Object Modeling and Fusion Deposition Modeling, Electron Beam Melting.	L2
CO3	Students will be able to point out the applications of Rapid Prototyping particularly in product design & development, medical, tooling, fashion & jewellery, architecture and automotive fields.	L3
CO4	Students will be able to define virtual prototyping and identify simulation components.	L4

Course Content

UNIT-I

Introduction to RP: Need & Development of RP systems, RP process chain, Impact of Rapid prototyping and Tooling on Product Development, Benefits, Digital prototyping, Virtual prototyping.

RP Applications: Design, Concept Models, Form & fit checking, Ergonomic Studies, Functional testing, Requesting Price quotes, CAD data verification, Rapid Tooling, Rapid manufacturing, Science & Medicine, Archeology, Paleontology & forensic Science, miniaturization.

UNIT-II

Liquid and Solid Based Rapid Prototyping Systems: Stereo lithography Apparatus, Fused deposition Modeling, Laminated object manufacturing, 3D printing: Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

Powder Based Rapid Prototyping Systems: Selective Laser Sintering, Direct Metal Laser Sintering, 3D Printing, Laser Engineered Net Shaping, Selective Laser Melting, Electron Beam Melting: Processes, materials, products, advantages, applications and limitations.

UNIT-III

Data Processing for Rapid Prototyping: Process planning for rapid prototyping, CAD model preparation, Data Requirements & geometric modeling techniques: Wire frame, surface and solid modeling data formats - Data interfacing, Tessellation of surfaces, STL file generation Defects in STL files and repairing algorithms, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation.

Issues of Rapid Prototyping parts: Accuracy issues in Rapid Prototyping, Strength of RP Parts, Surface roughness problem in Rapid Prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost, material, color, dimensional accuracy, stability, machine-ability, environmental resistance, operational properties.

UNIT-IV

Rapid Tooling: Classification: Soft tooling, Production tooling, Bridge tooling; direct and indirect, Fabrication processes, Applications, Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering, vacuum casting, use of Rapid tooling for injection mold.

Reverse Engineering: Introduction to reverse engineering, integration of reverse engineering and rapid prototyping, use of RP for reverse engineering.

Text and Reference Books

1. Rapid Prototyping: Principle and Applications, Rafiq I Noorani, Wiley & Sons, 2006
2. Rapid prototyping: Principles and applications, Chua C.K., Leong K.F., and Lim C.S., Yes Dee Publishing Pvt. Ltd, Third edition,2010.
3. Rapid Prototyping And Engineering Applications, Frank W. Liou, CRC Press, Special Indian Edition, 2007.
4. Journey from Rapid Prototyping to Rapid Manufacturing , Somnath Chattopadhyaya, LAP Lambert Academic Publishing,,2011.
5. Rapid Prototyping Technology: Selection and Application, Kenneth G. Cooper, Cooper Cooper, Marcel Dekker Inc, 1st Edition, 2001.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	--	--	--	2	--	--	--	--	--	--	3	3	2	1
CO2	3	--	--	--	2	--	--	--	--	--	--	3	3	2	1
CO3	3	3	3	--	2	--	--	--	--	--	2	3	3	2	2
CO4	3	--	2	--	3	--	--	--	--	--	2	3	3	2	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

Professional Elective -V

Course Code	Course Name	L	T	P	Credits
PEC-ME464-T	Power Plant Engineering	3	-	-	3.0
PEC-ME465-T	Solar Energy Engineering	3	-	-	3.0
PEC-ME466-T	Design of Heat Exchangers	3	-	-	3.0
PEC-ME467-T	Turbo Machinery	3	-	-	3.0
PEC-ME468-T	Computational Fluid Dynamics	3	-	-	3.0

POWER PLANT ENGINEERING (THEORY)

General Course Information

Course Code: PEC-ME464-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to define and state various thermal power plants.	L1
CO2	Students will be able to classify, compare and explain different power plants.	L2
CO3	Students will be able to demonstrate the constructional details and working principle of power plants.	L3
CO4	Students will be able to differentiate conventional/non-conventional/ direct energy conversion devices and power plants.	L4
CO5	Students will be able to evaluate the performance, operating characteristics and electrical energy costing of a given thermal power plants.	L5

Course Content

UNIT-I

Introduction: Energy resources and their availability, types of power plants, selection of the plants, review of basic thermodynamic cycles used in power plants.

Hydro Electric Power Plants : Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plants design, construction and operation of different components of hydro-electric power plants, site selection, comparison with other types of power plants.

UNIT-II

Steam Power Plants: Flow sheet and working of modern-thermal power plants, super critical pressure steam stations, site selection, coal storage, preparation, coal handling systems, feeding and burning of pulverized fuel, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator.

Combined Cycles: Constant pressure gas turbine power plants, Arrangements of combined plants (steam & gas turbine power plants), re-powering systems with gas production from coal, using PFBC systems, with organic fluids, parameters affecting thermodynamic efficiency of combined cycles. Problems.

UNIT-III

Nuclear Power Plants: Principles of nuclear energy, basic nuclear reactions, nuclear reactors-PWR, BWR, CANDU, Sodium graphite, fast breeder, homogeneous; gas cooled. Advantages and limitations, nuclear power station, waste disposal.

Power Plant Economics: load curve, different terms and definitions, cost of electrical energy, tariffs methods of electrical energy, performance & operating characteristics of power plants- incremental rate theory, input-out put curves, efficiency, heat rate, economic load sharing, Problems.

UNIT-IV

Non-Conventional Power Generation: Solar radiation estimation, solar energy collectors, low, medium & high temperature power plants, OTEC, wind power plants, tidal power plants, geothermal power plants.

Direct Energy Conversion Systems: Fuel cell, MHD power generation-principle, open & closed cycles systems, thermoelectric power generation, thermionic power generation.

Text and Reference Books

1. Power Plant Engineering –Arora & Domkundwar, Dhanpat Rai & Co, 2011.
2. Power Plant Engineering –Samsher Gautam, Vikash publications, 2013.
3. Power Plant Engineering –P.C. Sharma, Katson Books, 2010.
4. Power Plant Engineering –G.D. Rai, Khanna Publishers, 2010.
5. Power Plant Engineering –R.K. Rajput, Laxmi Publishers, 2012.
6. Power station Engineering and Economy by B. G.A. Skrotzki and W.A. Vopat, Mc Graw Hill Publishing Campany Ltd., New Delhi.
7. Power Plant Engineering- P.K. Nag Tata McGraw Hill second Edition, 2001.
8. Power Plant Engg.- M.M. El-Wakil McGraw Hill, 1985.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO2	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO3	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO4	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO5	3	3	2	1	--	2	1	1	2	2	2	3	3	3	1

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

SOLAR ENERGY ENGINEERING (THEORY)

General Course Information

Course Code: PEC-ME465-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to state heating/cooling and electrical applications of solar engineering.	L1
CO2	Students will be able to classify and explain different solar energy based devices/equipments and their effects on environment.	L2
CO3	Students will be able to use different solar based equipments/appliances for various domestic applications.	L3
CO4	Students will be able to examine performance of various solar engineering equipments/devices.	L4
CO5	Students will be able to evaluate the thermal performance of solar based equipments.	L5

Course Content

Unit- I

Introduction to solar system: Introduction, solar system – sun, earth and earth-sun angles, time, derived solar angles,

Solar Radiation: Estimation of solar radiation (direct and diffuse), measurement systems – phyrheliometers and other devices.

Unit-II

Effect of Solar radiation upon structures: Steady state heat transmission, solar radiation properties of surfaces, shading of surfaces, periodic heat transfer through walls and roofs.

Solar Collectors: Flat plate and concentrating – comparative study, design and materials, efficiency, selective coatings, heliostats.

Unit-III

Heating Applications of Solar Energy: Air and Water heating systems, thermal storages, solar ponds, solar pumps, solar lighting systems, solar cookers, solar drying of grains.

Cooling Applications of Solar Systems: Continuous and intermittent vapour absorption systems for cooling applications, absorbent – refrigerant combination, passive cooling systems.

Unit-IV

Solar Electric Conversion Systems: Photovoltaics, solar cells, satellite solar power systems.

Effects on Environment: economic scenario, ozone layer depletion, green house effect, global warming, Remedial measures by international bodies.

Text and Reference Books

1. Solar Energy: Fundamentals, Design, Modelling and Applications - GN Tiwari, CRC Press
2. Solar Energy – S P Sukhatme, Tata McGraw Hill
3. Solar Energy Process – Duffie and Bechman, John Wiley
4. Applied Solar Energy – Maniel and Maniel, Addison Wiley
5. Solar Energy: Fundamentals and Applications – R P Garg and Jai Prakash, TMH.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	--	2	2	1	1	2	1	3	3	3	2
CO2	3	3	2	1	--	2	3	1	1	2	1	3	3	3	3
CO3	3	3	2	1	--	2	2	1	1	2	1	3	3	3	2
CO4	3	3	3	1	--	2	2	1	1	2	1	3	3	3	2
CO5	3	3	3	1	--	2	2	1	2	2	1	3	3	3	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

DESIGN OF HEAT EXCHANGERS (THEORY)

General Course Information

Course Code: PEC-ME466-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to define and state heat exchangers used in various engineering applications.	L1
CO2	Students will be able to classify, compare and explain different heat exchangers.	L2
CO3	Students will be able to solve the problems related to the design parameters of a heat exchanger.	L3
CO4	Students will be able to differentiate and examine various heat exchangers.	L4
CO5	Students will be able to evaluate the thermal performance/sizing/heat transfer coefficients of a heat exchanger.	L5

Course Contents

UNIT-I

Classification of Heat exchangers: Introduction, Recuperation and regeneration, Transfer processors, Geometry of construction–tubular heat exchangers, plate heat exchangers, extended surface heat exchanges, Heat transfer mechanisms, Flow arrangements, Selection of heat exchangers.

Basic Design Methods of Heat Exchanges: Introduction, Arrangement of flow path in heat exchangers , Basic equations in design, Overall heat transfer coefficient , Log mean temperature difference method for heat exchanger analysis, The ε-NTU method for heat exchanger analysis, Heat exchanger design calculation, Variable overall heat transfer coefficient , Heat exchanger design methodology.

UNIT-II

Design Correlations for Condensers and Evaporators: Introduction, Condensation, Film condensation on a single horizontal tube-laminar film condensation, forced convection, Film condensation in tube bundles-effect of condensate inundation, effect of vapor shear, Combined effects of inundation and vapor shear, Condensation inside tubes-condensation in vertical tubes, Flow boiling-subcooled boiling, flow pattern, flow boiling correlations.

Shell and Tube Heat Exchangers: Introduction, Basic components-shell types, tube bundle types, tubes and tube passes, tube layout, baffle type and geometry, allocation of streams, Basic design procedure of a heat exchanger-preliminary estimation of unit size, rating of preliminary design, Shell-slide heat transfer and pressure drop-shell-side heat transfer coefficient, shell-side pressure drop, tubeside pressure drop, Bell-Delaware method.

UNIT-III

Compact Heat Exchangers: Introduction, Plate-fin heat exchangers, tube-fin heat exchangers, Heat transfer and pressure drop-heat transfer, pressure drop for finned-tube exchangers, pressure drop for plate-fin exchangers.

Gasketed Plate Heat Exchangers: Introduction, Mechanical features-plate pack and frame, plate types, Operational characteristics-main advantages, performance limits, Passes and flow arrangements, Application-corrosion, maintenance, Heat transfer and pressure drop calculations heat transfer area, mean flow channel gap, channel equivalent diameter, heat transfer coefficient, channel pressure drop, port pressure drop, overall heat transfer coefficient, heat transfer surface area, performance analysis, Thermal performance.

UNIT-IV

Condensers and Evaporators: Introduction, Shell-and-tube condensers-horizontal shell-side condensers, vertical shell-side condensers, vertical tube-side condensers, horizontal in-tube condensers, Steam turbine exhaust condensers, Plate condensers, Air-cooled condensers, Direct contact condensers, Thermal design of shell-and-tube condensers, Design and operational considerations, Condensers for refrigeration and air-conditioning-water cooled condensers, aircooled condensers, evaporative condensers, Evaporative for refrigeration and airconditioning-water-cooling evaporators (chillers), air-cooling evaporators (air coolers), Thermal analysis-shah correlation, Kandlikar correlation, Gungor and Winterton correlation, Standards for evaporators and condensers.

Regenerators: Classifications-fixed bed regenerators, rotary regenerators, basic design method, Influence of fluid bypass carry-over, Pressure drop evaluation, The rating problem, surface geometrical properties, Pressure drop, Sizing problem.

Text and Reference Books

1. Compact Heat Exchangers: Selection, Application, Design and Evaluation, Bahman Zohuri, 2017.
2. Heat Exchanger Design Guide – practical guide for planning, selecting and designing of shell and tube exchangers, Dr. Manfred Nitsche and Mr. R.O. Gbadamosi, Essevier, 2015.
3. Heat Exchanger Design Handbook, Second Edition,Kuppan Thulukkanam, CRC press, 2013.
4. Fundamentals of heat exchanger design, R.K. Shah, Jon Wily & Sons, 2003.
5. Fundamentals of heat exchanger design, Ramesh K. Shah, Dusan P. Sekulic, John Wiley & Sons, 2003.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO2	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO3	3	3	3	1	--	2	1	1	1	2	1	3	3	3	1
CO4	3	3	2	1	--	2	1	1	1	2	1	3	3	3	1
CO5	3	3	3	1	--	2	1	1	2	2	1	3	3	3	1

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

TURBO MACHINERY (THEORY)

General Course Information

Course Code: PEC-ME467-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to define application of thermodynamics and fluid mechanics.	L1
CO2	Students will be able to describe the analyses of practical gas turbine and propulsion cycles.	L2
CO3	Students will be able to examine the performance characteristics of gas turbines	L3
CO4	Students will be able to develop different turbo machineries.	L4

Course Content

UNIT-I

Review of Basics: Introduction to Prime Movers, Gas Turbines, Review of Basic principles – Thermodynamics, Review of Basic principles – Fluid Dynamics and Heat Transfer, Fundamentals of Rotating Machines – Energy Equation, Dimensional Analysis, Airfoil Theory.

Ideal Gas Turbine Cycles: Analysis of Ideal Gas Turbine Cycles, Simple Cycle, Regeneration Cycle, Reheat Cycle, Inter cooling Cycle.

UNIT-II

Practical Gas Turbine Cycles: Analysis of Practical Gas Turbine Cycles, Methods of accounting for component losses, Efficiencies, changes in the composition of the working fluid.

Propulsion Cycles: Jet Propulsion Cycles and their Analysis for turbojet, turboprop and turbofan engines-efficiency and specific thrust Factors Affecting Flight Performance & Methods of Thrust Augmentation.

UNIT-III

Gas Turbines: Axial Flow Gas Turbines – Impulse and reaction Turbines, Single Impulse stage, Single Reaction stage, Performance characteristics.

Rankine Cycle: Properties of Pure Substances, Property diagrams, Steam Power plant Layout, Rankine Cycle-Analysis, Modified Rankine Cycle, and Combined Cycle.

UNIT-IV

Steam Nozzles: Steam Nozzles: Introduction, Area- velocity relationship, Mass flow rate, Choking of Nozzles, Performance characteristics of Nozzles, Super saturated flow Steam Turbines: Steam Turbines : Impulse and reaction

Turbines, Compounding of steam turbines, Multistage reaction Turbines, Reheat factor and Efficiency, Governing of Steam Turbines

Text and Reference Books

1. Principles of turbomachinery, Seppo A. Korpela, Wiley, 2011.
2. Fundamentals of turbomachinery, B.K. venkanna, PHI, 2009
3. Fundamentals of turbomachinery, William W.Peng, Willey, 2007.
4. Turbomachinery: Physics and Dynamics, Meinhard T. Schobeiri, Springer, 2005.
5. Tribo-Machinery Dynamics, A.S. Rangwala, Mc Graw Hill, 2005.

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	--	1	1	1	1	2	1	3	3	3	1
CO2	3	3	3	2	--	1	1	1	1	2	1	3	3	3	1
CO3	3	3	3	2	--	1	1	1	1	2	1	3	3	3	1
CO4	3	3	3	2	--	1	1	1	1	2	1	3	3	3	1

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)

COMPUTATIONAL FLUID DYNAMICS (THEORY)

General Course Information

Course Code: PEC-ME468-T Course Category: Professional Elective Course Course Credits: 3.0 Contact Hours: 3 hours/week (L: 3; T: 0) Mode: Lectures Examination Duration: 3 hours	**Course Assessment Methods (internal: 30; external: 70)** Two minor tests each of 20 marks, Class Performance measured through percentage of lectures attended (4 marks) Assignment and quiz (6 marks), and end semester examination of 70 marks. For the end semester examination, nine questions are to be set by the examiner. Question number one will be compulsory and based on the entire syllabus. It will contain seven short answers type questions. Rest of the eight questions is to be given by setting two questions from each of the four units of the syllabus. A candidate is required to attempt any other four questions selecting one from each of the remaining four units. All questions carry equal marks.

Course Outcomes

Sr. No.	Course Outcome	RBT Level
CO1	Students will be able to define the fundamental of CFD and its various approach.	L1
CO2	Students will be able to understand the governing equations for heat and fluid flow.	L2
CO3	Students will be able to solve the heat transfer and fluid flow problem using CFD	L3
CO4	Students will be able to compare the finite volume and finite difference methods	L4

Course Contents

UNIT-I

Introduction: Introduction to C.F.D., models of the flow, governing differential equations – continuity equation, momentum equation, energy equation, Navier- stokes equation, physical boundary conditions.

Mathematical behavior of governing equation: Classification of quasi linear partial differential equation, General method of determining the Classification of partial differential equation, hyperbolic, parabolic, elliptic equations.

UNIT-II

Heat conduction problem: Solution of One dimensional heat conduction through a pin fin by F.D.M solution of two dimensional heat conductional in a plate by F.D.M. Control volume formulation of the heat conduction problem and its solution. Discretization methods: Finite difference methods, difference equations, explicit & implicit approach, errors & analysis of stability. Basics of finite control volume method, errors & analysis of stability

UNIT-III

Heat conduction with convection & diffusion: Steady state one dimensional convection and diffusion, unwinding, exact solution, exponential scheme, hybrid scheme, power law scheme, Discretization equation for two dimensions & three dimensions, false diffusion

UNIT-IV

Fluid flow problem: Viscous incompressible flow, solution of the couette flow problem by F.D.M., calculation of the flow field using stream function –vorticity method numerical algorithms for solving complete navier stokes equation – MAC method; SIMPLE method.

Text and Reference Books

1. Versteeg, H. and Malalasekra, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Education, New Delhi (2008).
2. Wendt, J. F., Computational Fluid Dynamics: An Introduction, Springer, New York (2009)
3. Muralidhar, K and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa, New Delhi
4. Jaluria, Y and Torrance, K.E., Computational Heat Transfer, Hemisphere Publishing Company, New York
5. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Company, New York
6. John David Anderson, Computational Fluid Dynamics: The Basics with Applications, Mcgraw hill education

Course Articulation Matrix (CO to PO/PSO Mapping)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1	3	1	1	--	--	2	1	3	3	2	3
CO2	3	1	2	2	2	--	1	1	2	2	--	3	3	2	2
CO3	3	3	2	3	3	2	2	1	2	2	--	3	2	1	2
CO4	3	2	--	2	3	--	--	--	2	2	--	3	--	--	2

1 : (Slight/Low), 2:(Moderate/Medium), 3 :(Substantial/High)