PRIYADARSHINI COLLEGE OF ENGINEERING, NAGPUR
DEPARTMENT OF MECHANICAL ENGINEERING
Scheme of Examination for B.Tech. in Mechanical Engineering 2025-26

V Semester

Sr. No.	Course Code	Category	BOS/ Dept	Course Name	Hours/ Week			Credits	Maximum Marks			ESE Duration (Hrs.)
					L	T	P		Continuous Evaluation	End Semester Exam	Total	
1	25UME501T	PC-PCC	ME	Manufacturing Processes	3			3	40	60	100	03
2	25UME501P	PC-PCC	ME	Manufacturing Processes			2	1	25	25	50	
3	25UME502T	PC-PCC	ME	Strength of Materials	4			4	40	60	100	03
4	25UME502P	PC-PCC	ME	Strength of Materials			2	1	25	25	50	
5	25UME503T	PC-PCC	ME	Heat Transfer	3			3	40	60	100	03
6	25UME503P	PC-PCC	ME	Heat Transfer			2	1	25	25	50	
7	25UME5XXT	PC-PEC	ME	PEC-I	3			3	40	60	100	03
8	25UME504P	MC-MDM	ME	Employability Enhancement Skill			4	2	50		50	
9	25UME5XXT	MC-OE	ME	Open Elective-03	2			2	20	30	50	02
10	25UME505P	PC-PCC	ME	MATLAB Programming			2	1	25	25	50	
Total					**15**		**12**	**21**	**330**	**370**	**700**	**14**

V Semester

Programme Elective Course (PEC)-I		
S.N.	**Course Code**	**Course Name**
1	25UME521T	Advanced Manufacturing Techniques
2	25UME522T	Industrial Robotics,
3	25UME523T	Internal Combustion Engines,
4	25UME524T	Production Planning and Control
5	25UME525T	Material Handling Systems
6	25UME526T	Introduction to Computational Fluid Dynamics

Open Elective-03		
S. N.	**Course Code**	**Course Name**
1	25UOE550T	Industrial Robotics
2	25UOE551T	Introduction to Renewable Energy Sources
3	25UOE552T	Industrial Safety & Environment

Multidisciplinary Minor (MDM)		
S.N	**Course Code**	**Course Name**
1	25UME504P	Employability Enhancement Skill

Theory	Practical
05	**05**

Course Title	**:**	**Manufacturing Processes**		**Semester**	**:**	**V**
Course Code	**:**	**25UME501T**		**Course Category**	**:**	**PC-PCC**
Teaching Scheme	**:**	**L - T - P** **3 - 0 - 0**		**Total Credits**	**:**	**3**

Prerequisites:

- Students should have prior knowledge of Engineering Materials, Basic Engineering Mechanics, and Fundamentals of Thermodynamics.

Course Objectives:

- To explain various casting processes, solidification principles, and defect analysis in metal casting.
- To describe bulk and sheet metal forming processes and their influence on material properties.
- To classify different welding and joining techniques, including their advantages, limitations, and applications.
- To illustrate powder metallurgy and ceramic processing techniques used for manufacturing advanced materials.
- To examine modern manufacturing processes, including additive and hybrid manufacturing, for industrial applications.
- To describe plastics processing techniques and their role in manufacturing polymer-based products.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Analyze different metal casting processes and identify suitable applications based on process characteristics. (4)

CO2. Apply suitable metal forming techniques for different materials and product requirements. (3)

CO3. Analyze welding defects and suggest appropriate methods to improve weld quality. (4)

CO4. Apply powder metallurgy and ceramic processing principles to develop components with desirable properties. (3)

CO5. Apply modern manufacturing techniques such as 3D printing and Industry 4.0 technologies for innovative product development. (4)

CO6. Select appropriate plastic forming techniques based on material properties and application requirements. (3)

Course Content:

Unit 1: Metal Casting Processes
8 Hrs.
Types of Casting Processes (Sand Casting, Investment Casting, Die Casting, Centrifugal Casting, etc.) Pattern Making and Allowances Molding Materials and Cores Solidification of Metals and Casting Defects Gating and Riser Design
Unit 2: Metal Forming Processes
7 Hrs.
Introduction to Bulk Deformation Processes Rolling, Forging, Extrusion, and Wire Drawing Sheet Metal Forming: Deep Drawing, Bending, Shearing, and Stretch Forming Formability of Materials and Defects in Forming High Energy Rate Forming (HERF)
Unit 3: Welding and Joining Processes
7 Hrs.
Classification of Welding Processes Gas Welding, Arc Welding, and Resistance Welding Advanced Welding Techniques: Laser Welding, Electron Beam Welding, Friction Stir Welding Brazing and Soldering Welding Defects and Testing Methods
Unit 4: Powder Metallurgy and Ceramic Processing
8 Hrs.
Powder Metallurgy: Introduction, Powder Production, Blending, Compaction, and Sintering Applications and Advantages of Powder Metallurgy Ceramic Processing Techniques Comparison of Powder Metallurgy with Conventional Manufacturing Processes
Unit 5: Plastics Processing and Polymer Manufacturing
8 Hrs.
Introduction to Plastics: Classification, Properties, and Applications Plastics Processing Techniques: Extrusion, Injection Moulding, Blow Moulding, Compression Moulding, Transfer Moulding, Calendaring, Embossing Wire Drawing and Forming of Plastics Polymer Composites and Their Applications Recycling and Sustainability in Plastics Manufacturing
Unit 6: Non-Conventional and Modern Manufacturing Techniques
8 Hrs.
Additive Manufacturing: 3D Printing and Rapid Prototyping Hybrid Manufacturing Systems Micro and Nano-Manufacturing

Industry 4.0 and Smart Manufacturing Sustainable and Green Manufacturing Practices

Textbooks:

- Manufacturing Science, A.G. Rao & Amitabha Ghosh, East-West Press
- Manufacturing Engineering and Technology, Serope Kalpakjian & Steven R. Schmid, Pearson Education
- Manufacturing Technology: Foundry, Forming, and Welding, P.N. Rao, McGraw-Hill Education
- Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Mikell P. Groover, John Wiley & Sons

Reference Book:

- Principles of Metal Casting, Richard W. Heine, Carl R. Loper, Philip C. Rosenthal, McGraw-Hill Education
- Metal Forming: Mechanics and Metallurgy, William F. Hosford & Robert M. Caddell, Cambridge University Press
- Welding and Joining of Advanced High Strength Steels (AHSS), John G. Speer, Mahdi M. Atabaki, Woodhead Publishing
- Powder Metallurgy: Science, Technology, and Materials, Anish Upadhyaya & Gopal S. Upadhyaya, Cambridge University Press
- Plastic Product Material and Process Selection Handbook, Eric R. Larson, Elsevier
- Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David Rosen, Brent Stucker, Springer

Course Title	:	**Manufacturing Processes**		**Semester**	:	**V**
Course Code	:	**25UME501P**		**Course Category**	:	**PC-PCC**
Teaching Scheme	:	**L - T - P** **0 - 0 - 2**		**Total Credits**	:	**1**

Prerequisites:

- Students should have prior knowledge of respective theory from the subject 25UME501T - Manufacturing Processes

Course Objectives:

- Explain the fundamental principles of metal casting processes, including mold preparation and gating system design.
- Analyze the deformation behavior of metals in forging and extrusion processes.
- Apply sheet metal forming techniques to manufacture products with minimal defects.
- Compare different welding processes to determine their suitability for various engineering applications.
- Perform additive manufacturing and polymer processing techniques for product development.
- Implement sustainable manufacturing practices, including recycling and hybrid manufacturing.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Apply casting techniques and design an efficient gating and riser system for defect-free casting. (3)

CO2. Analyze the influence of process parameters on material flow in forging and extrusion. (4)

CO3. Perform sheet metal forming and evaluate factors affecting surface quality and material behavior. (3)

CO4. Compare the quality of welded joints in different welding processes and suggest improvements. (4)

CO5. Develop polymer-based components and prototypes using additive manufacturing. (3)

CO6. Implement hybrid manufacturing and recycling techniques to improve sustainability. (3)

List of Experiments

1. Sand Molding and Casting
2. Gating and Riser Design in Casting
3. Forging Process – Open Die and Closed Die Forging
4. Extrusion and Wire Drawing
5. Sheet Metal Forming – Bending and Deep Drawing
6. Arc Welding and Gas Welding
7. TIG & MIG Welding
8. Powder Metallurgy – Compaction and Sintering
9. Additive Manufacturing – 3D Printing
10. Polymer Processing – Injection Molding & Extrusion
11. Hybrid Manufacturing – Combining Conventional & Additive Manufacturing
12. Recycling of Plastic Waste and Sustainable Manufacturing

Textbooks:

- Manufacturing Science, A.G. Rao & Amitabha Ghosh, East-West Press
- Manufacturing Engineering and Technology, Serope Kalpakjian & Steven R. Schmid, Pearson Education
- Manufacturing Technology: Foundry, Forming, and Welding, P.N. Rao, McGraw-Hill Education

Reference Book:

- Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Mikell P. Groover, John Wiley & Sons
- Principles of Metal Casting, Richard W. Heine, Carl R. Loper, Philip C. Rosenthal, McGraw-Hill Education
- Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David Rosen, Brent Stucker, Springer

Experiments mapped with Course Objectives & Course Outcomes

Exp. No.	Title	Mapped COB	Mapped CO
1	Sand Molding and Casting	COB 1	CO 1
2	Gating and Riser Design in Casting	COB 1	CO 1
3	Forging Process – Open Die and Closed Die Forging	COB 2	CO 2
4	Extrusion and Wire Drawing	COB 2	CO 2
5	Sheet Metal Forming – Bending and Deep Drawing	COB 3	CO 3
6	Arc Welding and Gas Welding	COB 3	CO 3
7	TIG & MIG Welding	COB 4	CO 4
8	Powder Metallurgy – Compaction and Sintering	COB 4	CO 4
9	Additive Manufacturing – 3D Printing	COB 5	CO 5
10	Polymer Processing – Injection Molding & Extrusion	COB 5	CO 5
11	Hybrid Manufacturing – Combining Conventional & Additive Manufacturing	COB 6	CO 6
12	Recycling of Plastic Waste and Sustainable Manufacturing	COB 6	CO 6

Course Objectives and Mapped Experiment Numbers

Sr. No.	Course Objective	Mapped Experiment
1	Explain the fundamental principles of metal casting processes, including mold preparation and gating system design.	1, 2
2	Analyze the deformation behavior of metals in forging and extrusion processes.	3, 4
3	Apply sheet metal forming techniques to manufacture products with minimal defects.	5, 6
4	Compare different welding processes to determine their suitability for various engineering applications.	7, 8
5	Perform additive manufacturing and polymer processing techniques for product development.	9, 10
6	Implement sustainable manufacturing practices, including recycling and hybrid manufacturing.	11, 12

Course Outcomes and Mapped Experiment Numbers

Sr. No.	Course Objective	Mapped Experiment No.
1	Apply casting techniques and design an efficient gating and riser system for defect-free casting.	1, 2

2	Analyze the influence of process parameters on material flow in forging and extrusion.	3, 4
3	Perform sheet metal forming and evaluate factors affecting surface quality and material behavior.	5, 6
4	Compare the quality of welded joints in different welding processes and suggest improvements.	7, 8
5	Develop polymer-based components and prototypes using additive manufacturing.	9, 10
6	Implement hybrid manufacturing and recycling techniques to improve sustainability.	11, 12

Course Title	:	Strength of Materials		Semester	:	V
Course Code	:	25UME502T		Course Category	:	PC-PCC
Teaching Scheme	:	L - T - P 4 - 0 - 0		Total Credits	:	4

Prerequisites:

- Basic Physics, Basic Mathematics and basic mechanics, including concepts like forces, moments, equilibrium, stress, strain, and basic material properties.

Course Objectives:

- Apply stress-strain fundamentals for analyzing axial loading in members and material deformation.
- Interpret complex stress states and evaluate principal stresses in structural components.
- Evaluate internal forces and stresses in beams subjected to different loading conditions.
- Compute deflection and strain energy in beams under various static and dynamic loading cases.
- Investigate torsional behavior in shafts under combined loading conditions.
- Analyze the stability and failure of columns using critical load theories.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Calculate axial stresses, strains, thermal effects, and deformation in homogeneous and composite bars under static loading. (3)

CO2. Determine principal stresses and planes using analytical methods and graphical tools such as Mohr's circle. (3)

CO3. Draw shear force and bending moment diagrams and evaluate bending and shear stresses in structural members. (3)

CO4. Compute slope, deflection, and strain energy in beams using standard methods like Macaulay's method. (3)

CO5. Solve problems related to torsional loading in circular shafts, including equivalent stresses under combined loads. (3)

CO6. Calculate buckling loads for columns with different end conditions using Euler's and empirical formulas. (3)

Course Content:

Unit I
10 Hrs.
Concept of simple stresses and strains: Introduction, stress, strain, types of stresses, stress and strain diagram for brittle & ductile material, elastic limit, Hooks law, modulus of elasticity, modulus of rigidity, factor of safety, analysis of tapered rod, analysis of composite section, thermal stress and strain. Longitudinal strain & stress, lateral stresses and strains, Poisson's ratio, volumetric stresses and strain with uni-axial, bi-axial & tri-axial loading, bulk modulus, relation between Young's modulus and modulus of rigidity, Poisson's ratio and bulk modulus.
Unit II
6 Hrs.
Principal stresses and strains:- Definition of principal planes & principal stresses, analytical method of determining stresses on oblique section when member is subjected to direct stresses in one plane in mutually perpendicular two planes, when member is subjected to shear stress and direct stresses in two mutually perpendicular planes, Mohr's circle for representation of principal stresses
Unit III
10 Hrs.
Shear force and bending moments in Beam: Types of beam (cantilever beam, simply supported beam, overhung beam etc.), Types of loads (Concentrated and UDL), shear force and bending moment diagrams for different types of beams subjected to different types of loads, sign conventions for bending moment and shear force, shear force and bending moment diagrams for beams subjected to couple, Relation between load, shear force and bending moment Bending and shear stresses in beams: Theory of simple bending, bending equation, section modulus, bending stresses in symmetrical and unsymmetrical sections, composite beams, beam of uniform strength. Shear stress equation, shear stresses across standard sections and built up sections. Compound stresses in beam.
Unit IV
10 Hrs.
Deflection of beams:- Deflection & slope of cantilever, simply supported, overhung beams subjected to concentrated load, UDL, Relation between slope, deflection & radius curvature Macaulay's method to determine deflection of beam. Strain energy & impact loading: - Definition of strain energy stored in a body when it is subjected to gradually applied load, suddenly applied loads & impact loads. Strain energy stored in bending & torsion
Unit V
6 Hrs.
Torsion of circular shafts: - Derivation of torsion equation with the assumptions made in it. Torsion shear stress induced in the shaft, when it is subjected to torque. Strength and rigidity criterion for design of shaft. Torque transmitted by solid & hollow circular shaft. Equivalent twisting and bending moment in shaft when it is subjected to bending moment, torque & axial load.

Unit VI
6 Hrs.
Column & Struts: Failure of long & short column, slenderness ratio, Euler's column theory, End conditions for column. Expression for crippling load for various end conditions of column. Effective length of column, limitations of Euler's formula, Rankine formula, Johnson's parabolic formula.

Textbooks:

- Strength of Materials, Ramamrutham S., Dhanpat Rai Publishing.
- Strength of Materials, S.S. Rattan, McGraw-Hills Education (India) Publication.

Reference Book:

- Engineering Mechanics of Solid by Egor P. Popov, Prentice Hall of India Publication.
- Mechanics of Materials by Beer, Johnson, Dewolf, Mc Graw Hill Publication.
- Mechanics of materials by Timoshenko and Gere, CBS Publisher.

Course Title	:	**Strength of Material**		**Semester**	:	**V**
Course Code	:	**25UME502P**		**Course Category**	:	**PC-PCC**
Teaching Scheme	:	**L - T - P** **0 - 0 – 2**		**Total Credits**	:	**1**

Prerequisites:

- Students should have prior knowledge of Engineering Materials, Basic Engineering Mechanics, and Fundamentals of Thermodynamics.

Course Objectives:

- To create specimens and analyze microstructures of ferrous and non-ferrous materials using metallographic techniques.
- To test and evaluate mechanical properties of engineering materials including hardness, impact strength, and hardenability.
- To study the behavior of materials under various static and dynamic loading conditions.
- To examine the structural response of beams and other components under different loading scenarios.
- To investigate material failure modes and performance through standardized testing methods.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Analyze the microstructure and evaluate mechanical properties of ferrous and non-ferrous materials; interpret stress-strain behavior under different loading conditions.(4)

CO2. Analyze the effects of tensile and shear forces and apply the knowledge gained to solve real-life engineering problems for different material types.(4)

CO3. Interpret microstructures and correlate them with material applications in engineering components.(2)

CO4. Measure torsional strength and surface hardness of engineering materials using appropriate testing methods.(3)

CO5. Apply material behavior concepts in the selection and design of mechanical components.(3)

List of Experiments

1. To study the Metallurgical Microscopes & Preparation of specimen for metallographic examination.
2. Micro-structural examination of different types of Steels
3. Micro-structural study of White Cast Iron and Grey Cast Iron
4. Micro-structural study of Malleable Cast Iron and Nodular Cast Iron
5. To Study of Universal Testing Machine
6. Determination of tensile properties of ductile material
7. Determination of properties of brittle material
8. Compression tensile test on materials
9. Shear test on metals
10. Impact test on materials
11. The Tension Test by using Universal Testing Machine
12. Determination of bending strength by deflection of beam
13. Measurement of hardness with the help of Rockwell Hardness Tester
14. Measurement of hardness with the help of Brinell Hardness Tester
15. Study of Universal Testing Machine (U.T.M.)

Textbooks:

- Strength of Materials by S. Ramamrutham and R. Narayanan, Dhanpat Rai Publishing Company (P) Ltd, 18th Edition 2017.Mechanical Engg. Design, Shigley, TMH.
- Strength of Materials by R.K. Bansal, Laxhmi Publications, New Delhi, 6th edition, 2017

Reference Book:

- Elements of Strength of Materials by Timoshenko, S.P. and Young, D.H., East West Press, 5th edition, 2011.
- S. P. Timoshenko, "History of Strength Of materials", Dover Publications, 1953.

Experiments mapped with Course Objectives & Course Outcomes

Exp. No.	Title	Mapped COB	Mapped CO
1	Study of Metallurgical Microscope & Specimen Preparation	COB 1	CO1
2	Microstructural Examination of Different Types of Steels	COB 1	CO1
3	Microstructural Study of White and Grey Cast Iron	COB 1	CO1
4	Microstructural Study of Malleable and Nodular Cast Iron	COB 1	CO1
5	Study of Universal Testing Machine (UTM)	COB 5	CO5
6	Tensile Test on Ductile Material	COB 2	CO2
7	Tensile Test on Brittle Material	COB 2	CO2
8	Compression Test on Materials	COB 3	CO2
9	Shear Test on Metals	COB 3	CO2
10	Impact Test on Materials	COB 2	CO2
11	Tension Test using Universal Testing Machine	COB 2	CO2
12	Bending Test – Deflection of Beam	COB 4	CO4
13	Hardness Test using Rockwell Hardness Tester	COB 2	CO4
14	Hardness Test using Brinell Hardness Tester	COB 2	CO4
15	Re-study and Demonstration of Universal Testing Machine (UTM)	COB 5	CO5

Course Objectives and Mapped Experiment Numbers

Sr. No.	Course Objective	Mapped Experiment No.
1	To create specimens and analyze microstructures of ferrous and non-ferrous materials using metallographic techniques.	1, 2, 3, 4
2	To test and evaluate mechanical properties of engineering materials including hardness, impact strength, and hardenability.	6, 7, 10, 11, 13, 14
3	To study the behavior of materials under various static and dynamic loading conditions.	8, 9
4	To examine the structural response of beams and other components under different loading scenarios.	12
5	To investigate material failure modes and performance through standardized testing methods.	5, 15

Course Outcomes and Mapped Experiment Numbers

Sr. No.	Course Outcome	Mapped Experiment No.
1	Analyze the microstructure and evaluate mechanical properties of ferrous and non-ferrous materials; interpret stress-strain behavior under different loading conditions.	1, 2, 3, 4
2	Analyze the effects of tensile and shear forces and apply the knowledge gained to solve real-life engineering problems for different material types.	6, 7, 8, 9, 10, 11
3	Interpret microstructures and correlate them with material applications in engineering components.	2, 3, 4
4	Measure torsional strength and surface hardness of engineering materials using appropriate testing methods.	12, 13, 14
5	Apply material behavior concepts in the selection and design of mechanical components.	5, 15

Course Title	**:**	**Heat Transfer**		**Semester**	**:**	**V**
Course Code	**:**	**24UME503T**		**Course Category**	**:**	**PC-PCC**
Teaching Scheme	**:**	**L - T - P** **3 - 0 - 0**		**Total Credits**	**:**	**3**

Prerequisites:

- Basic of heat transfer and heat transfer mode

Course Objectives:

- Apply basic laws of heat transfer to solve steady-state conduction problems in various geometries.
- Develop conduction models with internal heat generation and analyze heat transfer through fins.
- Investigate forced convection heat transfer using boundary layer concepts and empirical relations.
- Examine free convection, boiling, and condensation phenomena for thermal systems.
- Apply radiation laws to evaluate heat exchange between black and grey surfaces.
- Analyze performance of heat exchangers using LMTD and NTU methods for various flow arrangements.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Solve one-dimensional steady-state conduction problems and compute overall thermal resistance in composite structures. (3)

CO2. Analyze temperature distribution and heat dissipation in extended surfaces with and without internal heat generation. (3)

CO3. Calculate convective heat transfer coefficients for internal and external flows using empirical correlations. (3)

CO4. Evaluate free convection heat transfer and phase change mechanisms like boiling and condensation. (3)

CO5. Perform radiation heat transfer calculations using surface properties and geometric configuration factors. (3)

CO6. Compute heat exchanger effectiveness and outlet temperatures using LMTD and NTU methods. (3)

Course Content:

Unit I
8 Hrs.
Introduction, Basic modes of Heat Transfer, Conduction, Convection & Radiation. Laws of Heat transfer, General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates. One dimensional steady state heat conduction equation for the plane wall, cylinder and sphere, Overall heat transfer coefficient. Thermal resistance of composite structure, contact resistance.
Unit II
8 Hrs.
Conduction with internal heat generation for plane wall, Cylinder and Sphere. Extended surface, Types of Fins, Fins of uniform cross section area, temperature distribution and their heat transfer rate, Fin efficiency & Effectiveness
Unit III
7 Hrs.
Forced convection, Concept of hydrodynamics & thermal boundary layer thickness, local and average heat transfer coefficient. Empirical co-relations for external, internal flows, laminar & turbulent flow through conduits.
Unit IV
8 Hrs.
Free or Natural Convection, Grashof's number, Rayleigh number, flow over horizontal and vertical plate, Empirical co-relations for cylinders and sphere. Boiling and Condensation heat transfer: Pool boiling curve and regimes of pool boiling, Film and Drop wise condensation
Unit V
7 Hrs.
Radiation, black body radiation, radiation intensity, Laws of radiation-Kirchhoff, Planck's, Wien's displacement law, Stefan Boltzmann & Lamberts Co-sine law. Emissivity, Absorptivity, Transmissivity, Reflectivity, Radiosity, Emissive power, Irradiation. Radiation exchange between surfaces, , radiation between parallel plates, Radiation shields
Unit VI
7 Hrs.
Heat exchanger: Detail Classification, Overall Heat Transfer Coefficient, Fouling Factor, LMTD & Effectiveness for parallel and counter flow heat exchanger, NTU method of heat exchanger analysis for parallel and counter flow arrangement.

Textbooks:

- Fundamentals of Heat & Mass Transfer, Incropera, F.P., Dewitt, D. P., John Wiley & Sons
- Heat Transfer, J.P. Holman, McGraw Hill Book Company, New York.
- Fundamentals of Heat and Mass Transfer, K. N. Seetharam & T.R. Seetharam, Willey.
- Engineering Heat and Mass Transfer, M.M. Rathor, Laxmi PublicationsPvt. Ltd.

Reference Book:

- Fundamentals of Heat and Mass Transfer, Venkanna B.K., PHI Publication.
- Principles of Heat Transfer, Frank Kreith, Harper and Row Publishers, New York.
- Heat Transfer - A Practical Approach, Yunus A. Cengel, Tata McGraw Hill Publishing Company Ltd., New Delhi.
- Heat & Mass Transfer, M.N. Ozisik, Tata McGraw Hill Publishing Company Ltd., New Delhi.
- 5. Heat & Mass Transfer, R.K. Rajput, Laxmi Publication.

DATA BOOK:

- Heat & Mass Transfer, Domkundwar, Dhanapat Rai & Sons Publication.
- Heat & Mass Transfer, C.P.Kothandaraman,PHI publishers.

Course Title	:	Heat Transfer		Semester	:	V
Course Code	:	25UME503P		Course Category	:	PC-PCC
Teaching Scheme	:	L - T - P 0 - 0 – 2		Total Credits	:	1

Prerequisites:

- Basic knowledge of Heat Transfer and it's modes of heat transfer

Course Objectives:

- To determine thermal conductivity of various materials such as metals, insulating powders, and composite walls.
- To evaluate heat transfer performance under natural and forced convection and analyze different condensation modes.
- To verify radiation heat transfer principles by determining the Stefan-Boltzmann constant and emissivity.
- To examine the effectiveness and characteristics of heat exchangers under various operating conditions.
- To study and demonstrate advanced thermal systems including heat pipes and virtual simulations.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Determine the thermal conductivity of insulating powder, metal bar and composite wall. (3)

CO2. Determine the heat transfer coefficient in natural and forced convection and differentiate between film wise and dropwise condensation. (4)

CO3. Determine Stefan Boltzmann constant. (3)

CO4. Determine the emissivity of a test body. (3)

CO5. Describe the various types of heat exchangers and heat pipes. (2)

List of Experiments

1. To determine the thermal conductivity of insulating material
2. To determine the thermal conductivity of metal bar
3. Determination of thermal conductivity of composite wall
4. Determination of Stefan Boltzmann constant
5. Determination of heat transfer coefficient in natural convection for vertical tube
6. To determine heat transfer coefficient in forced convection for fluid flowing through duct
7. Determination of temperature distribution & heat transfer rate from fin
8. Determination of emissivity of non-black body
9. To determine the effectiveness of a concentric tube heat exchanger
10. To determine the heat transfer coefficient in film wise and dropwise condensation
11. Study of various types of Heat Exchangers
12. Study of Heat Pipe
13. Minimum 1–2 virtual experiments to be conducted

Textbooks:

- Heat and Mass Transfer – R.K. Rajput, S. Chand & Company Ltd.
- Fundamentals of Engineering Heat and Mass Transfer – R.C. Sachdeva, New Age International
- Heat Transfer – J.P. Holman, McGraw-Hill Education

Reference Book:

- Heat Transfer – Yunus A. Cengel, McGraw-Hill Education
- Principles of Heat Transfer – Frank Kreith, Cengage Learning
- Process Heat Transfer – D.Q. Kern, McGraw-Hill

Experiments mapped with Course Objectives & Course Outcomes

Exp. No.	Title	Mapped COB	Mapped CO
1	To determine the thermal conductivity of insulating material	COB 1	CO1
2	To determine the thermal conductivity of metal bar	COB 1	CO1
3	Determination of thermal conductivity of composite wall	COB 1	CO1
4	Determination of Stefan Boltzmann constant	COB 3	CO3
5	Determination of heat transfer coefficient in natural convection for vertical tube	COB 2	CO2
6	To determine heat transfer coefficient in forced convection for fluid flowing through duct	COB 2	CO2
7	Determination of temperature distribution & heat transfer rate from fin	COB 2	CO2
8	Determination of emissivity of non-black body	COB 3	CO4
9	To determine the effectiveness of a concentric tube heat exchanger	COB 4	CO5
10	To determine the heat transfer coefficient in film wise and dropwise condensation	COB 2	CO2
11	Study of various types of Heat Exchangers	COB 4	CO5
12	Study of Heat Pipe	COB 5	CO5
13	Minimum 1–2 virtual experiments to be conducted	COB 5	All COs

Course Objectives and Mapped Experiment Numbers

Sr. No.	Course Objective	Mapped Experiment No.
1	To determine thermal conductivity of various materials such as metals, insulating powders, and composite walls.	1, 2, 3
2	To evaluate heat transfer performance under natural and forced convection and analyze different condensation modes.	5, 6, 7, 10
3	To verify radiation heat transfer principles by determining the Stefan-Boltzmann constant and emissivity.	4, 8
4	To examine the effectiveness and characteristics of heat exchangers under various operating conditions.	9, 11
5	To study and demonstrate advanced thermal systems including heat pipes and virtual simulations.	12, 13

Course Outcomes and Mapped Experiment Numbers

Sr. No.	Course Outcome	Mapped Experiment No.
1	Determine the thermal conductivity of insulating powder, metal bar and composite wall.	1, 2, 3
2	Determine the heat transfer coefficient in natural and forced convection and differentiate between film wise and dropwise condensation.	5, 6, 7, 10
3	Determine Stefan Boltzmann constant.	4
4	Determine the emissivity of a test body.	8
5	Describe the various types of heat exchangers and heat pipes.	9, 11, 12

Course Title	**:**	**Advanced Manufacturing Techniques**		**Semester**	**:**	**V**
Course Code	**:**	**25UME521T**		**Course Category**	**:**	**PC-PEC**
Teaching Scheme	**:**	**L - T - P** **3 - 0 - 0**		**Total Credits**	**:**	**3**

Prerequisites:

- Basic knowledge of conventional manufacturing processes, material behavior, machine tools, and process flow in manufacturing systems.

Course Objectives:

- To explore non-traditional machining processes based on mechanical energy.
- To analyze electro-thermal and electro-chemical machining techniques and their applications.
- To investigate beam-based advanced machining processes for precision manufacturing.
- To examine additive manufacturing technologies and their implementation.
- To study micro and nano manufacturing methods used in emerging applications.
- To identify hybrid processes and evaluate current advancements in intelligent manufacturing.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Classify and compare mechanical energy-based advanced machining processes in terms of working principles, process parameters and applications. (2)

CO2. Analyze material removal mechanisms in electro-thermal and electro-chemical processes and assess their industrial relevance. (4)

CO3. Explain the principles and process capabilities of laser and plasma-based machining techniques for high-precision applications. (2)

CO4. Evaluate various additive manufacturing methods and select suitable techniques for different engineering applications. (4)

CO5. Describe micro and nano-manufacturing techniques and their integration in multidisciplinary fields. (2)

CO6. Assess the role of hybrid and intelligent manufacturing systems in modern production environments. (4)

Course Content:

Unit I – Advanced Machining Processes
8 Hrs.
Need for non-traditional machining processes Classification of advanced machining processes Abrasive Jet Machining (AJM): Working principle, process parameters, applications, advantages & limitations Water Jet Machining (WJM): Process setup, working, applications Ultrasonic Machining (USM): Mechanism, equipment, tool design, material removal rate Comparison with conventional machining processes
Unit II – Electro-Thermal and Electro-Chemical Processes
7 Hrs.
Electric Discharge Machining (EDM): Working principle, process parameters, tool and dielectric selection Wire EDM: Mechanism, flushing techniques, accuracy, applications Electrochemical Machining (ECM): Principle, electrode design, electrolyte selection, applications Comparative analysis of EDM and ECM: Advantages, limitations, and areas of application
Unit III – Laser and Plasma Beam Machining
8 Hrs.
Fundamentals of Laser Beam Machining (LBM): Laser generation, properties, and material interaction Process parameters, applications, and limitations of LBM Plasma Arc Machining (PAM): Generation of plasma, mechanism, process parameters Application areas, material compatibility, and safety measures in LBM and PAM Comparative advantages of beam-based processes in precision machining
Unit IV – Additive Manufacturing Techniques
7 Hrs.
Introduction to Additive Manufacturing (AM): Need and evolution Classification of AM processes Fused Deposition Modeling (FDM): Principle, material used, advantages Stereolithography (SLA): Process setup, photopolymerization, applications Selective Laser Sintering (SLS): Powder materials, sintering mechanism, accuracy Advantages, limitations, and challenges in AM
Unit V – Micro and Nano Manufacturing
8 Hrs.
Introduction to micro-manufacturing and nano-manufacturing Micro-EDM and Micro-ECM: Principles, tool design, process control Laser-based micro-machining: Pulse lasers, resolution, control systems Nanoimprint lithography: Techniques, molds, pattern transfer Applications in electronics, biomedical, automotive, and MEMS Challenges in micro/nano-scale manufacturing
Unit VI – Hybrid Manufacturing Processes and Recent Trends

7 Hrs.
Concept and need for hybrid manufacturing Hybrid techniques: Electrochemical Discharge Machining (ECDM), Electrochemical Arc Machining (ECAM) Abrasive-based hybrid processes: Principle and examples Recent trends in advanced manufacturing: 5-axis CNC machining Industry 4.0 in manufacturing Robotics in intelligent manufacturing Digital twins and smart factories Role of sensors and data in cyber-physical production systems

Textbooks

- Advanced Machining Processes, V.K. Jain, Allied Publishers.
- Manufacturing Science, Ghosh & Malik, East West Press.
- Fundamentals of Advanced Manufacturing Processes, Amitabha Ghosh, New Central Book Agency.

Reference Books

- Manufacturing Engineering and Technology, Kalpakjian & Schmid, Pearson Education.
- Production Technology, HMT, Tata McGraw-Hill.
- Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Mikell P. Groover, Wiley.

Course Title	:	**Industrial Robotics**		**Semester**	:	**V**
Course Code	:	**25UME522T**		**Course Category**	:	**PC-PEC**
Teaching Scheme	:	**L - T - P** **3 - 0 - 0**		**Total Credits**	:	**3**

Prerequisites:

- Basic Physics, Basic Mathematics and Fluid Mechanics

Course Objectives:

- To provide foundational knowledge of industrial robots and their classification.
- To enable understanding of robotic components such as actuators, sensors, and controllers.
- To introduce basic kinematics and motion planning in robotics.
- To explore robotic integration in automation and manufacturing systems.
- To highlight emerging applications of robotics in various industries.
- To develop awareness of future trends, ethical, and social aspects of robotics.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1 To classify types of industrial robots and describe their structural components and applications.

CO2 To identify and explain the function of various robotic actuators, sensors, and controllers.

CO3 To apply basic kinematics and control principles for robot motion planning and analysis.

CO4 To illustrate the role of robots in industrial automation and smart manufacturing.

CO5 To explain the use of robots in healthcare, logistics, agriculture, and other emerging fields.

CO6 To discuss future trends in robotics, including AI integration and ethical considerations.

Course Content:

Unit I: Introduction to Industrial Robotics
8 Hrs.
Definition and classification of robots History and evolution of industrial robotics Basic structure and components of an industrial robot Robot degrees of freedom and workspace Industrial applications in Manufacturing, Healthcare, Agriculture, Logistics
Unit II: Robotic Components and Sensors
7 Hrs.
Types of actuators: Electric, Hydraulic, Pneumatic Basics of robotic sensors: Proximity, Vision, Force, Tactile End effectors and grippers: Types and uses Introduction to robotic controllers and programming logic
Unit III: Robot Kinematics and Motion Control
7 Hrs.
Forward and Inverse Kinematics (conceptual approach) Introduction to robotic motion planning Robot drive mechanisms and trajectory planning Basics of control systems: PID, Open-loop, Closed-loop
Unit IV: Industrial Automation and Smart Robotics
8 Hrs.
Use of robots in Industry 4.0 and smart factories Collaborative robots (Cobots): Features and safety aspects Case studies in industrial automation Role of robotics in lean and flexible manufacturing
Unit V: Emerging Applications of Robotics
8 Hrs.
Robotics in healthcare: Surgery, rehabilitation, elderly care Autonomous robots in transportation and logistics Service robots in domestic, security, hospitality sectors Agricultural and hazardous environment robotics
Unit VI: Future Trends and Ethical Aspects
8 Hrs.
AI and Machine Learning in robotics Cloud robotics, IoT, and HRI (Human-Robot Interaction) Ethical, legal, and social implications Future career opportunities and global impact

Textbooks:

- Introduction to Robotics: Mechanics and Control – John J. Craig, Pearson
- Industrial Robotics: Technology, Programming, and Applications – Mikell P. Groover, McGraw-Hill
- Robotics: Modelling, Planning and Control – Siciliano et al., Springer

Reference Book:

- Fundamentals of Robotics: Analysis and Control – Robert J. Schilling
- Robot Modeling and Control – Mark W. Spong et al.
- Artificial Intelligence for Robotics – Francis X. Govers

Course Title	**:**	**Internal Combustion Engines,**		**Semester**	**:**	**V**
Course Code	**:**	**25UME523T**		**Course Category**	**:**	**PC-PEC**
Teaching Scheme	**:**	**L - T - P** **3 - 0 - 0**		**Total Credits**	**:**	**3**

Prerequisites:

- Basic Physics, Basic Mathematics and Fluid Mechanics

Course Objectives:

- To explain construction, classification, and operating principles of internal combustion engines and their thermodynamic cycles.
- To describe properties of IC engine fuels and analyze fuel supply systems used in SI and CI engines.
- To examine combustion phenomena, flame propagation, and knocking in spark ignition engines.
- To investigate combustion stages and abnormal combustion phenomena in compression ignition engines.
- To explain engine cooling and lubrication systems and assess their functional importance.
- To calculate engine performance parameters and conduct testing using standard procedures and instruments.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Classify IC engines and compare Otto, Diesel, and Dual cycles along with 2-stroke and 4-stroke engine operations. (2)

CO2. Analyze fuel characteristics and evaluate fuel supply mechanisms in SI and CI engines using theoretical and numerical approaches. (3)

CO3. Describe stages of combustion and analyze factors affecting flame propagation and knocking in SI engines. (2)

CO4. Explain combustion behavior in CI engines and assess causes and control of knocking and abnormal combustion. (3)

CO5. Compare air and liquid cooling systems and assess the role of different lubrication systems in engine performance. (2)

CO6. Calculate engine performance parameters and prepare heat balance sheets using test data. (3)

Course Content:

Unit I
8 Hrs.
Introduction, Definition and Function of IC Engine, Various nomenclature of IC Engine, Classification of I.C Engines, Working of Otto cycle, Diesel cycle and dual cycle on basis of PV Diagram, Working of 4 Stroke and 2 stroke ,S.I and C.I engines, Comparison of S.I and C.I Engines,
Unit II
7 Hrs.
I.C engine fuels, Important qualities of SI and CI engine fuels, Rating of SI & CI engine fuels. SI engine Fuel supply system- Types of fuel supply used, working of simple carburetor and its limitations C.I. Engine Fuel supply system, components of Fuel injection system, D.I. systems and CRDI, types of nozzles. (Numerical on carburetor and fuel injection system)
Unit III
7 Hrs.
Combustion in SI Engines- Introduction, stages of combustion, Combustion Chambers, Factors controlling combustion chamber design, flame front propagation, factors affecting flame front propagation, Abnormal combustion in SI Engine, Knock in SI engines, variables affecting Knocking.
Unit IV
8 Hrs.
Combustion in C. I. Engines: Charge motion within the cylinder, Air swirl, Methods to generate air swirl, Stages of combustion in C. I. engines, Ignition delay period, factors affecting delay period, Abnormal combustion CI Engine, Factor responsible for abnormal combustion and its control, Variables affecting knocking.
Unit V
8 Hrs.
Engine Cooling System: Cooling requirement, Air cooling, Type of liquid cooling system, Advantage and disadvantage of air cooling and water cooling system. Lubrication System: Function of lubricating system, Properties of lubricating oil, Wet sump, Dry sump and mist lubrication system.
Unit VI
8 Hrs.
Engine performance parameter and Testing: Definitions of important engine characteristics of engines Brake, Torque & Power, Mechanical efficiency, Mean effective pressure, Specific fuel consumption and efficiency, Volumetric efficiency. Testing - Measurement of friction power, indicated power (indicator diagram), Brake power, various types of absorption dynamometer, Fuel consumption measurement, Air consumption measurement methods, Heat balance sheet.

Textbooks:

- Internal Combustion Engines, V. Ganesan, Tata McGraw-Hill.
- A Textbook of Internal Combustion Engines, R.K. Rajput, Laxmi Publications.
- Internal Combustion Engine, M.L. Mathur & R.P. Sharma, Dhanpat Rai Publications.

Reference Book:

- Internal Combustion Engines and Air Pollution, Obert E.F., Harper & Row Publishers.
- Engineering Fundamentals of the Internal Combustion Engine, Willard W. Pulkrabek, Pearson Education.
- The Internal Combustion Engine in Theory and Practice, Charles Fayette Taylor, MIT Press.

Course Title	**:**	**Production Planning and Control**		**Semester**	**:**	**V**
Course Code	**:**	**25UME524T**		**Course Category**	**:**	**PC-PEC**
Teaching Scheme	**:**	**L - T - P** **3 - 0 - 0**		**Total Credits**	**:**	**3**

Prerequisites:

- Basic knowledge of manufacturing processes, industrial management principles, and elementary mathematical techniques used in engineering decision-making.

Course Objectives:

- To explain the structure and functions of production planning and control in manufacturing systems.
- To apply forecasting techniques for effective production planning decisions.
- To analyze capacity planning methods and production scheduling based on demand.
- To apply inventory control models and material requirement planning systems.
- To evaluate production control functions including scheduling, sequencing, and dispatching.
- To develop aggregate and manpower planning using optimization and line balancing methods.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Differentiate between production planning and control functions and describe their role in various manufacturing systems. (2)

CO2. Apply demand forecasting techniques such as moving average, exponential smoothing, and least squares for production planning. (3)

CO3. Analyze effective capacity and formulate a master production schedule considering system constraints. (4)

CO4. Select appropriate inventory models and plan material requirements using MRP concepts. (3)

CO5. Explain production control functions such as loading, sequencing, scheduling, and dispatching. (2)

CO6. Formulate aggregate production plans using line balancing and linear programming techniques. (4)

Course Content:

Unit I-Production Planning
8 Hrs.
Introduction, Production Planning and Production Control, Functions and Objectives of PPC, Production procedure, information requirement Of PPC. Manufacturing Methods and PPC, Product Life Cycle. Product design.
Unit II-Demand Forecasting
7 Hrs.
Forecasting and Prediction. Long-term and short term forecasting. Times series analysis. Least square method. Exponential smoothening method. Moving Average forecasting.
Unit III-Capacity Planning
7 Hrs.
Introduction, Measurement and measures o£ capacity. Factors influencing effective capacity. Factors favoring over capacity and under capacity, Master Production Schedule.
Unit IV-Inventory Control
8 Hrs.
Introduction,. Types of inventories. Reasons for keeping inventories, inventory control, benefits of inventory control. Cost associated with inventory. Inventory cost relationships, safety stock. Inventory models, deterministic models. Material Requirement planning (MRP): Stochastic models. Inventory Control system. Introduction, Objectives of MRP, MRP-I, MRPII, Lot sizing consideration.
Unit V-Production Control
8 Hrs.
Introduction, loading, sequencing, priority sequencing, scheduling, dispatching and progressing.
Unit VI-Process Planning and Aggregate
8 Hrs.
Machine Manpower Planning, line balancing. Aggregate planning, linear programming approach to aggregate planning.

Textbooks:

- Buffa , Modern Production operations management, Willey eastern, New York
- Martand Telsang , Industrial Engineering and Productions Management, S. Chand, New Delhi (2009)
- Paneer Selvan R, Production and Operations Mangement , Prentince Hall , New Delhi (2002)
- Production and Operations Management, S.N. Chary, McGraw-Hill Education.
- Production Planning and Control, S. Panneerselvam, PHI Learning.
- Modern Production/Operations Management, Buffa & Sarin, Wiley India.

Reference Books

- Elements of Production Planning and Control, Eilon Samuel, Universal Book Stall.
- Operations Management, William J. Stevenson, McGraw-Hill Education.
- Production and Operations Management, R. Panneerselvam, PHI Learning.

Course Title	:	Material Handling Systems		Semester	:	V
Course Code	:	25UME525T		Course Category	:	PC-PEC
Teaching Scheme	:	L - T - P 3 - 0 - 0		Total Credits	:	3

Prerequisites:

- Basic knowledge of manufacturing processes, mechanical systems, and industrial equipment used in material movement and logistics.

Course Objectives:

- To
- To describe classification, selection, and working principles of material handling systems and equipment.
- To analyze technical and economic factors influencing the choice of material handling equipment.
- To explore lifting mechanisms, attachments, and various types of cranes used in industrial operations.
- To explain working principles of hoisting systems and accessories used for handling diverse loads.
- To examine various types of conveyor systems and apply selection criteria for industrial applications.
- To study surface transport equipment and evaluate their applications in modern material handling systems.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Classify material handling systems and select appropriate equipment based on application requirements. (2)

CO2. Analyze material handling problems and perform economic evaluation of equipment selection. (4)

CO3. Identify suitable lifting attachments and explain the application of different types of industrial cranes. (2)

CO4. Describe construction and working of manual, electric, and pneumatic hoisting systems. (2)

CO5. Select appropriate conveyor systems based on design considerations and material flow. (3)

CO6. Explain the principles and applications of surface transport equipment including automated guided vehicles. (2)

Course Content:

Unit I
8 Hrs.
Introduction to material handling system and classification of material handling equipments, selection of material handling equipment, Types of handling system including screw type, hydraulic pneumatic and hoisting equipment.
Unit II
7 Hrs.
Type of material and loads, transport capacity, Lenght of conveying and direction of conveying , method of stacking at initial intermediate and final points-specific load conditions, Fundamental types of material handling problems, Different approaches to analyze material handling problems, Economic Analysis of material handling systems.
Unit III
7 Hrs.
Lifting Methods: Lifting tackles, lifting and rigging Load handling attachments Various types of hooks-forged, eye bolts, eye hook, electric lifting magnet, vacuum lifter, grabbing attachment for loose materials, crane attachment for handling liquids/ molten metal's. Types of cranes and Industrial Lifts: cranes with a fixed post, jib cranes with trolley, rotary cranes, trackless cranes, mobile cranes, bridge cranes, cable cranes, floating cranes and cranes traveling on guide rails. Introduction to types of Industrial Lifts.
Unit IV
8 Hrs.
Hoisting Systems: Working and principles of various hoists systems portable hand chain hoist, lever assisted hoist, hand chain hoist, differential hoist, worm and spur geared assisted hoist, electric and pneumatic hoists,Appliances for suspending hooks-crane grab for unit and piece loads
Unit V
8 Hrs.
Conveyor Systems : Introduction to conveyors, chain conveyors , belt conveyors, roller conveyors. Screw Conveyors. Bucket Conveyors, The general design considerations of conveyors and selection criterion in material handling system
Unit VI
8 Hrs.
Surface transport equipment: Fundamental Principles and working of trackless equipment such as hand operated trucks, powered trucks, Pallet trucks , Forklifts , AGV (Automated Guided vehicle), industrial trailers

Textbooks:

- Material Handling Equipment – R.B. Chowdary & G.N.R. Tagore, Khanna Publishers, Delhi
- Material Handling Equipment – M.P. Alexandrow, MIR Publishers, Moscow
- Plant Layout & Material Handling – Apple J.M., John Wiley Publishers

Reference Book:

- Conveyors and Related Equipment – Spivakovsy A.O. and Dyachkov V.K, MIR Publishers
- Material Handling (Principles & Practice) – Allegri T.H, CBS Publishers, Delhi
- Introduction to Material Handling – Siddhartha Ray, New Age International Publication

Course Title	:	**Introduction to Computational Fluid Dynamics**		**Semester**	:	**V**
Course Code	:	**25UME526T**		**Course Category**	:	**PC-PEC**
Teaching Scheme	:	**L - T - P** **3 - 0 - 0**		**Total Credits**	:	**3**

Prerequisites:

- Basic Physics, Basic Mathematics and Fluid Mechanics

Course Objectives:

- To introduce governing equations of fluid dynamics and explain conservation principles using partial differential equations.
- To explain discretization methods and demonstrate their role in solving steady-state diffusion problems.
- To apply finite volume techniques for solving unsteady and convection-diffusion problems in 1D.
- To evaluate higher-order convection schemes and apply them to 2D problems using finite volume formulation.
- To analyze solution algorithms such as SIMPLE/SIMPLER and solve Navier-Stokes equations using structured and unstructured grids.
- To explore turbulence modeling techniques and understand their role in real-world CFD simulations.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Classify partial differential equations and explain the structure of governing conservation equations in fluid dynamics. (2)

CO2. Apply finite volume and discretization methods to solve steady-state diffusion problems with boundary conditions. (3)

CO3. Implement numerical schemes to solve unsteady and convection-diffusion problems using finite volume method. (3)

CO4. Evaluate and compare higher-order discretization schemes such as QUICK and TVD for 2D convection-diffusion problems. (4)

CO5. Solve Navier-Stokes equations using iterative methods and apply SIMPLE/SIMPLER algorithms on different grid systems. (4)

CO6. Analyze turbulent flows using RANS equations and apply turbulence modeling techniques in CFD simulations. (4)

Course Content:

Unit I
8 Hrs.
Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour, Approximate Solutions of Differential Equations: Error Minimization Principles.
Unit II
7 Hrs.
Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Consistency, Stability and Convergence. 1-D Steady State Diffusion Problems- Source term linearization, Implementation of boundary conditions
Unit III
7 Hrs.
1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. Finite volume discretization of convection-diffusion problem. Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme
Unit IV
8 Hrs.
Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem. The concept of false diffusion, QUICK scheme, TVD schemes and flux limiter functions.
Unit V
8 Hrs.
Finite Volume Discretization of 2-D unsteady State Diffusion type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods Discretization of Navier Stokes Equations, primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation.
Unit VI
8 Hrs.
Introduction to Turbulence Modeling, Important features of turbulent flow, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling and applications. Laboratory practice.

Textbooks:

- An Introduction to Computational Fluid Dynamics: The Finite Volume Method – H.K. Versteeg & W. Malalasekera, Pearson Education, 2007
- The Finite Volume Method in Computational Fluid Dynamics: An Advanced Introduction with OpenFOAM and MATLAB – F. Moukalled, L. Mangani, M. Darwish, Springer, 2016
- Computational Fluid Dynamics – J.D. Anderson, McGraw-Hill

Reference Book:

- Numerical Heat Transfer and Fluid Flow – S.V. Patankar, Hemisphere Publishing Corporation, 1980
- Computational Fluid Dynamics – T.J. Chung, Cambridge University Press
- Computational Fluid Dynamics – Anderson & Wendt, McGraw-Hill, 1995

Course Title	:	**Industrial Robotics**		**Semester**	:	**V**
Course Code	:	**25UOE550T**		**Course Category**	:	**MC-OE**
Teaching Scheme	:	**L - T - P** **2 - 0 - 0**		**Total Credits**	:	**2**

Prerequisites:

Basic Mathematics and Physics, Basic Electrical and Electronics Engineering

Course Objectives:

- To introduce students to the fundamental concepts of industrial robotics and their applications in various industries.
- To explain the basic components of robotic systems, including sensors, actuators, and controllers.
- To provide an understanding of robotic kinematics and control with simplified mathematical concepts.
- To explore the applications of industrial robots in manufacturing, healthcare, and service industries.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Explain the fundamentals of industrial robotics and its role in automation. (2)

CO2. Describe the working principles of robotic components such as sensors, actuators, and controllers. (2)

CO3. Apply simple robotic kinematics and control concepts to basic motion planning. (3)

CO4. Analyze real-world applications of industrial robots in various sectors. (4)

Course Content:

Unit I: Introduction to Industrial Robotics
8 Hrs.
Definition and classification of robots History and evolution of industrial robotics Basic structure and components of an industrial robot Robot degrees of freedom and workspace Industrial applications of robots (Manufacturing, Healthcare, Agriculture, Logistics, etc.)
Unit II: Robotic Components and Sensors
7 Hrs.
Types of actuators used in robots (Electric, Hydraulic, Pneumatic) Basics of robotic sensors (Proximity, Vision, Force, and Tactile sensors) End effectors and grippers: Types and applications Introduction to robotic controllers and programming concepts

Unit III: Robot Kinematics and Motion Control
7 Hrs.
Basic concepts of robot kinematics (Forward and Inverse Kinematics – Conceptual Understanding) Introduction to robotic motion planning Robot drive mechanisms and trajectory planning Overview of robotic control systems (PID, Open-Loop, and Closed-Loop Control)
Unit IV: Applications and Future Trends in Robotics
8 Hrs.
Industrial robots in automation and smart manufacturing (Industry 4.0) Collaborative robots (Cobots) and their applications Robotics in healthcare, autonomous vehicles, and service industries AI and Machine Learning in robotics Future trends in robotics and ethical considerations

Textbooks:

- Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson Education
- Industrial Robotics: Technology, Programming, and Applications, Mikell P. Groover, McGraw-Hill
- Robotics: Modelling, Planning and Control, Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer

Reference Book:

- Fundamentals of Robotics: Analysis and Control, Robert J. Schilling, Prentice Hall
- Robot Modeling and Control, Mark W. Spong, Seth Hutchinson, M. Vidyasagar, Wiley
- Artificial Intelligence for Robotics, Francis X. Govers, Packt Publishing

Course Title	**:**	**Introduction to Renewable Energy Sources**		**Semester**	**:**	**V**
Course Code	**:**	**25UOE551T**		**Course Category**	**:**	**MC-OE**
Teaching Scheme	**:**	**L - T - P** **2 - 0 - 0**		**Total Credits**	**:**	**2**

Prerequisites:

- Basic Thermodynamics, Engineering Physics and Environmental Science.

Course Objectives:

- To explain the fundamentals of renewable energy sources and their role in sustainable development.
- To explain the principles, technologies, and applications of solar energy systems.
- To analyze wind energy systems, turbine selection, and biomass energy conversion methods.
- To evaluate the working principles and applications of hydro, geothermal, tidal, and other renewable energy sources.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Explain the importance of renewable energy and its role in mitigating environmental challenges.

CO2. Analyze the working principles, components, and applications of solar energy systems.

CO3. Evaluate wind energy systems, turbine selection, and biomass energy conversion techniques.

CO4. Compare different renewable energy sources such as hydropower, geothermal, and tidal energy for power generation.

Course Content:

Unit I- Introduction to Renewable Energy
8 Hrs.
Overview of energy sources: Renewable vs. Non-renewable energy. Importance of renewable energy, environmental impact, and sustainability. Global and Indian energy scenario, future energy demand and challenges. Energy conversion principles and efficiency.
Unit II- Solar Energy
7 Hrs.
Basics of solar radiation, measurement, and estimation. Solar thermal energy systems: Solar collectors, water heaters, dryers, and concentrators. Photovoltaic (PV) technology: Working principles, PV materials, efficiency, and applications. Solar power plants: Grid-connected and off-grid systems, advantages, and limitations.
Unit III- Wind and Biomass Energy

7 Hrs.
Basics of wind power, site selection, types of wind turbines, aerodynamics, power output, and applications. Wind power plant components, grid integration, and challenges. Biomass energy: Sources, biomass conversion technologies, biogas production, and biofuels. Environmental and economic aspects of wind and biomass energy
Unit IV- Hydro, Geothermal, and Other Renewable Energy Sources
8 Hrs.
Hydropower: Principles, types of hydroelectric plants, turbine selection, and small-scale hydro systems. Geothermal energy: Sources, types of geothermal plants, direct and indirect applications. Other renewable sources: Tidal, wave, and ocean thermal energy conversion (OTEC) technologies. Hybrid renewable energy systems and their potential for sustainable development.
Unit V
8 Hrs.
Unit VI
8 Hrs.

Textbooks:

- Renewable Energy: Power for a Sustainable Future - Boyle, G., Oxford University Press, 3rd Edition, 2012.
- Energy Technology: Non-Conventional - S. Rao & B.B. Parulekar, Renewable & Conventional, Khanna Publishers, 4th Edition, 2005.
- Non-Conventional Energy Sources - G.D. Rai, Khanna Publishers, 5th Edition, 2011.
- Renewable Energy Sources and Emerging Technologies - D.P. Kothari, K.C. Singal & Rakesh Ranjan, Prentice Hall of India, 2nd Edition, 2013.

Reference Book:

- Renewable Energy Resources - Twidell, J. & Weir, T., Routledge, 3rd Edition, 2015.
- Wind and Solar Power Systems: Design, Analysis, and Operation - Mukund R. Patel, CRC Press, 2nd Edition, 2005.
- Solar Energy: Principles of Thermal Collection and Storage - S.P. Sukhatme & J.K. Nayak, Tata McGraw-Hill, 3rd Edition, 2008.
- Principles of Solar Engineering, F. Kreith & J.F. Kreider, McGraw-Hill, 2nd Edition, 2000.
- Renewable Energy: Technology, Economics, and Environment - Martin Kaltschmitt, Wolfgang Streicher & Andreas Wiese, Springer, 2007.

Course Title	**:**	**Industrial Safety & Environment**		**Semester**	**:**	**V**
Course Code	**:**	**25UOE552T**		**Course Category**	**:**	**MC-OE**
Teaching Scheme	**:**	**L – T - P 2 – 0 -0**		**Total Credits**	**:**	**2**

Prerequisites:

- Basic knowledge of workshop practices and preliminary exposure to industrial environments through surveys or visits.

Course Objectives:

- To explain the principles of industrial safety and identify workplace hazards.
- To define the roles and responsibilities of safety management and its organizational framework.
- To describe legal frameworks related to industrial safety and evaluate statutory compliance.
- To outline safe working practices and develop emergency preparedness strategies.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. Identify safety hazards and explain the fundamentals of industrial safety and health policies. (2)

CO2. Explain administrative responsibilities and safety management functions within an organization. (2)

CO3. Interpret relevant acts and rules governing industrial safety practices. (3)

CO4. Apply safe work practices and develop emergency response plans for industrial environments. (3)

Course Content:

Unit I – Safety, Health and Environment
8 Hrs.
Importance of industrial safety Safety, health and environmental policies Accident causation and hazard identification: Fire, chemical, mechanical, electrical, radiation, environmental Safe engineering design principles
Unit II – Safety Organization and Administration
7 Hrs.
Objectives and scope of industrial safety programs Organizational responsibilities: Top management, middle management, workers Safety department structure Role of government bodies and social organizations in safety enforcement
Unit III – Legal Aspects of Industrial Safety

7 Hrs.
The Factories Act, 1948 The Maharashtra Factories Rules, 1963 Dangerous Machines (Regulation) Act, 1983 and Rules, 2007 Maharashtra Rules on Major Accident Hazards (2003) and Safety Audits (2014)
Unit IV – Safe Work Practices and Emergency Preparedness
8 Hrs.
Housekeeping, safety manuals, and SOPs Occupational health and safety policy Work permit systems, PPE usage, accident response and medical support Emergency planning, roles and responsibilities, evacuation, communication, public awareness, emergency control centers, and drills

Textbooks:

- Industrial Safety, Health and Environment Management Systems – R.K. Jain and Sunil S. Rao, Khanna Publishers
- Industrial Safety and Environment – Amit Gupta, Laxmi Publications Pvt. Ltd.
- Industrial Safety and Maintenance Management – M.P. Poonia and S.C. Sharma, Khanna Book Publishing

Reference Book:

- Safety and Health for Engineers – Roger L. Brauer, John Wiley & Sons, 2006
- Accident Prevention Manual for Industrial Operations – National Safety Council, Chicago, 1982
- Environmental Engineering – Gerard Kiely, McGraw Hill Education (India) Pvt. Ltd.

Course Title	:	MATLAB Programming		Semester	:	V
Course Code	:	25UME505P		Course Category	:	PC-PCC
Teaching Scheme	:	L - T - P 0 - 0 - 2		Total Credits	:	1

Prerequisites:

- Basic programming knowledge, Mathematical background, Basic mechanical engineering concepts

Course Objectives:

- Understand the MATLAB environment, programming syntax, and basic numerical operations.
- Develop MATLAB scripts and functions for solving mathematical and engineering problems.
- Apply MATLAB in mechanical engineering applications, including system modeling, signal processing, and control systems.
- Analyze real-world mechanical engineering problems using MATLAB simulations and visualization tools.

Course Outcomes: Upon successful completion of the course, students should be able to:

CO1. To demonstrate the use of MATLAB for basic programming, matrix operations, and numerical analysis. (2)

CO2. To implement MATLAB functions and scripts for solving engineering problems. (3)

CO3. To apply MATLAB for mechanical engineering applications such as system modeling and data analysis. (3)

CO4. To analyze real-world problems using MATLAB simulations and visualization tools. (4)

List of Experiments

2. Introduction to MATLAB environment and basic commands
3. Matrix operations and linear algebra in MATLAB
4. Plotting and visualization of functions in MATLAB
5. Writing MATLAB scripts and functions for basic computations
6. Solving algebraic and differential equations using MATLAB
7. Numerical integration and differentiation using MATLAB
8. Data analysis and curve fitting techniques in MATLAB
9. 1D Heat Transfer Analysis (Fourier's Law) using MATLAB
10. Basic Fluid Flow Visualization using MATLAB
11. Signal processing and Fourier analysis in MATLAB
12. Simple Kinematic Analysis of a Slider-Crank Mechanism
13. Mechanical system modeling using Simulink
14. Control system analysis and design using MATLAB
15. Vibration analysis of mechanical systems in MATLAB
16. Finite element method (FEM) basics using MATLAB
17. Optimization techniques and applications in MATLAB
18. Stress-Strain Curve Plotting from Experimental Data
19. Thermodynamic Property Estimation using MATLAB
20. Case Study on real-world mechanical engineering problems using MATLAB
21. Mini Project: Developing a MATLAB-based mechanical application

Textbooks:

- MATLAB: A Practical Introduction to Programming and Problem Solving – Stormy Attaway, Elsevier
- Applied Numerical Methods with MATLAB for Engineers and Scientists – Steven C. Chapra, McGraw-Hill
- Essential MATLAB for Engineers and Scientists – Brian Hahn, Daniel Valentine, Elsevier

Reference Book:

- MATLAB for Engineers – Holly Moore, Pearson
- MATLAB and Simulink for Engineers – A. Biran, M. Breiner, CRC Press
- Control System Design using MATLAB – Bahram Shahian, Michael Hassul, Pearson

Experiments mapped with Course Objectives C Course Outcomes

Exp. No.	Title	Mapped COB	Mapped CO
1	Introduction to MATLAB environment and basic commands	COB 1	CO 1
2	Matrix operations and linear algebra in MATLAB	COB 1	CO 1
3	Plotting and visualization of functions in MATLAB	COB 1	CO 1
4	Writing MATLAB scripts and functions for basic computations	COB 2	CO 2
5	Solving algebraic and differential equations using MATLAB	COB 2	CO 2
6	Numerical integration and differentiation using MATLAB	COB 2	CO 2
7	Data analysis and curve fitting techniques in MATLAB	COB 3	CO 3
8	1D Heat Transfer Analysis (Fourier's Law) using MATLAB	COB 3	CO 3
9	Basic Fluid Flow Visualization using MATLAB	COB 3	CO 3
10	Signal processing and Fourier analysis in MATLAB	COB 3	CO 3
11	Simple Kinematic Analysis of a Slider-Crank Mechanism	COB 3	CO 3
12	Mechanical system modeling using Simulink	COB 3	CO 3
13	Control system analysis and design using MATLAB	COB 4	CO 4
14	Vibration analysis of mechanical systems in MATLAB	COB 4	CO 4
15	Finite element method (FEM) basics using MATLAB	COB 4	CO 4

Exp. No.	Title	Mapped COB	Mapped CO
16	Optimization techniques and applications in MATLAB	COB 4	CO 4
17	Stress-Strain Curve Plotting from Experimental Data	COB 4	CO 4
18	Thermodynamic Property Estimation using MATLAB	COB 4	CO 4
19	Case Study on real-world mechanical engineering problems using MATLAB	COB 4	CO 4
20	Mini Project: Developing a MATLAB-based mechanical application	COB 4	CO 4

Course Objectives and Mapped Experiment Numbers

Sr. No.	Course Objective	Mapped Experiment No.
1	Understand the MATLAB environment, programming syntax, and basic numerical operations.	1, 2, 3
2	Develop MATLAB scripts and functions for solving mathematical and engineering problems.	4, 5, 6
3	Apply MATLAB in mechanical engineering applications, including system modeling, signal processing, and control systems.	7, 8, 9, 10, 11, 12
4	Analyze real-world mechanical engineering problems using MATLAB simulations and visualization tools.	13, 14, 15, 16, 17, 18, 19, 20

Course Outcomes and Mapped Experiment Numbers

Sr. No.	Course Outcome	Mapped Experiment No.
1	To demonstrate the use of MATLAB for basic programming, matrix operations, and numerical analysis. (2)	1, 2, 3
2	To implement MATLAB functions and scripts for solving engineering problems. (3)	4, 5, 6
3	To apply MATLAB for mechanical engineering applications such as system modeling and data analysis. (3)	7, 8, 9, 10, 11, 12
4	To analyze real-world problems using MATLAB simulations and visualization tools. (4)	13, 14, 15, 16, 17, 18, 19, 20