Study Scheme and Syllabus of

Master of Technology

Mechanical Engineering

For Batch 2025-27 and onwards

Study Scheme of M. Tech. Mechanical Engineering

SEMESTER 1st		Contact Hours/Week			Maximum Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
25C1MEP-101	Advanced Engineering Materials	4	0	0	50	100	150	4
25C1MEP-102	Finite Element Analysis	3	1*	0	50	100	150	4
25C1MEP-103	Advanced Design of Mechanical Systems	4	1*	0	50	100	150	4
25C1MEP-104	Operations Management	4	0	0	50	100	150	4
25C1MEP-105	Advanced Thermodynamics	4	0	0	50	100	150	4
Total		**18**	**2**	**0**	**250**	**500**	**750**	**20**
Total Contact Hours/Week = 20								

SEMESTER 2nd		Contact Hours/Week			Maximum Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
25C1MEP-201	Research Methodology	4	0	0	50	100	150	4
25C1MEP-202	Tribology	4	0	0	50	100	150	4
25C1MEP-203	Modern Manufacturing Processes	4	0	0	50	100	150	4
25C1MEP-204	Computational Fluid Dynamics	4	0	0	50	100	150	4
25C1MEP-PE1-XX	Elective –I	4	0	0	50	100	150	4
Total		**18**	**2**	**0**	**250**	**500**	**750**	**20**
Total Contact Hours/Week = 20								

SEMESTER 3rd		Contact Hours/Week			Maximum Marks			Credits
Subject Code	Subject Name	L	T	P	Int.	Ext.	Total	
25C1MEP-PE1-XX	Elective-II	4	0	0	50	100	150	4
25C1MEP-PE1-XX	Elective-III	4	0	0	50	100	150	4
25C1MEP-301	Project	-	-	12	50	50	100	6
25C1MEP-302	Seminar	-	-	4	100	----	100	2
Total		**8**	**0**	**16**	**250**	**250**	**500**	**16**
Total Contact Hours/Week = 24								

SEMESTER 4th		Contact Hours/Week			Evaluation Criteria	Credits
Subject Code	Subject Name	L	T	P		
25C1MEP-401	Dissertation	0	0	28	Satisfactory/Unsatisfactory	14
Total		**0**	**0**	**28**		**14**

List of Elective Subjects (Manufacturing & Industrial Engineering)

Code	Name of Subject
25C1MEP-PE1-01	Advanced Welding Technology
25C1MEP-PE1-02	Automation and Robotics
25C1MEP-PE1-03	Advanced Material Characterization Techniques
25C1MEP-PE1-04	Rapid Prototyping
25C1MEP-PE1-05	Advanced Metal Cutting
25C1MEP-PE1-06	Advanced Casting Processes
25C1MEP-PE1-07	Maintenance and Reliability Engineering
25C1MEP-PE1-08	Supply Chain Management
25C1MEP-PE1-09	Product Design and Development

List of Elective Subjects (Design)

Code	Name of Subject
25C1MEP-PE1-10	Engineering Design Optimization
25C1MEP-PE1-11	Advanced Vibration Engineering
25C1MEP-PE1-12	Mechatronics
25C1MEP-PE1-13	Dynamics of Rotating Machines
25C1MEP-PE1-14	Experimental Stress Analysis
25C1MEP-PE1-15	Sustainable Design and Manufacturing
25C1MEP-PE1-16	Vibration and Noise Control
25C1MEP-PE1-17	Composite Materials
25C1MEP-PE1-18	Instrumentation and Control Engineering

List of Elective Subjects (Thermal)

Code	Subjects
25C1MEP-PE1-19	Advanced Internal Combustion Engines
25C1MEP-PE1-20	Design of Steam Turbine
25C1MEP-PE1-21	Convective Heat Transfer
25C1MEP-PE1-22	Combustion Engineering
25C1MEP-PE1-23	Conductive & Radiative Heat Transfer
25C1MEP-PE1-24	Solar Energy Utilization
25C1MEP-PE1-25	Design of HVAC systems
25C1MEP-PE1-26	Design and Optimization of Thermal Systems
25C1MEP-PE1-27	Advanced Heat and Mass Transfer

Note:

(a) Student can opt Elective I, II &III subjects from the entire list electives as above.

(b) If a student selects all the three elective subjects form the same group of electives and also completes his / her project and dissertation in the same field, he /she may be awarded a separate / additional certificate indicating the more concentration in a particular field e.g. Manufacturing and Industrial, Design or Thermal of his / her M. Tech degree.

Course title	**Advanced Engineering Materials**
Course Code	**25C1MEP-101**
Scheme and Credits	**L T P C** **Semester – I** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	make use of the various properties of engineering materials.
CO 2	identify the basic properties and characteristics of composite materials.
CO 3	examine the basic properties of ceramics and glasses.
CO 4	utilize the basic aspects of low and high temperature advanced materials and their applications.
CO5	assess the basic properties, applications and developments of various smart materials.
CO6	analyse the basic aspects of nanomaterial and their applications, physical and mechanical properties.

UNIT 1: Classification and Selection of Materials (8 Hrs.)
Classification of materials, properties required in Engineering materials, Criteria of selection of materials, Requirements / needs of advance materials.

UNIT 2: Composite Materials (10 Hrs.)
Fiber reinforced, laminated and dispersed materials with metallic matrix of aluminium, copper and Titanium alloys and with non-metallic matrix of unsaturated polyesters and epoxy resins. Development, Important properties and applications of these materials.

UNIT 3: Ceramics and Glasses - Bio-ceramics (10 Hrs.)
Nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine.

UNIT 4: Low & High Temperature Materials (12 Hrs.)
Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available

for high temperature applications, Applications of low and high temperature materials.

UNIT 5: Smart Materials **(10 Hrs.)**

Shape Memory Alloys, Varistors and Intelligent materials for bio-medical applications, Polymers and Plastics from industry. Development, important properties and applications of these materials.

UNIT 6: Nanomaterials **(10 Hrs.)**

Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.

Suggested References/Books:

1. J.A. Jacobs and T.F. Kilduff, Engineering Material Technology, Prentice Hall, 1997.
2. W.D. Callister Jr., Materials Science and Engineering, Wiley India Pvt. Ltd., 2010.
3. G.E. Dieter, Engineering Design: A Materials and Processing Approach, McGraw-Hill, 1991.
4. M.F. Ashby, Materials Selection in Mechanical Design, Pergamon Press, 1992.
5. NIIT, Introduction to Engineering Materials and Manufacturing Processes, Prentice Hall of India, 2002.
6. K.G. Budinski, Engineering Materials: Properties and Selection, Prentice Hall of India, 1999.
7. G. Lewis, Selection of Engineering Materials, Prentice-Hall, New Jersey, 1995.

Course title	**FINITE ELEMENT ANALYSIS**
Course Code	**25C1MEP-102**
Scheme and Credits	**L T P C** **Semester – I** **3 1 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	identify the basic concepts of finite element methods and its applications to complex engineering problems.
CO 2	analyze the characteristics and selection of different finite elements used in finite element methods.
CO 3	evaluate the equilibrium equations and stress-strain relations for different boundary conditions encountered in structural, fluid and heat transfer problems.
CO 4	solve the basic problem related to structural, fluid and heat transfer problems.

UNIT 1: Introduction to Finite Element Method (8 Hrs.)

Basic concept, Historical background, engineering applications, general Description, comparison with other methods.

UNIT 2: Formulations and Variation Methods (10 Hrs.)

Need for weighted, integral forms, relevant mathematical concepts and formulae, weak formulation of boundary value problems, variational methods, Rayleigh –Ritz method and weighted residual approach.

UNIT 3: Finite Element Techniques (12 Hrs.)

Model boundary value problem, finite element discretization, element shapes, sizes And node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solution, post-processing, Compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermit Polynomials.

UNIT 4: Applications to Solid and Structural Mechanics Problems (12 Hrs.)

External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis symmetric and three dimensional stress-strain problems, strain displacement relations, boundary conditions compatibility equations, analysis of trusses, frames and solids of revolution, computer programs.

UNIT 5: Application to Heat Transfer Problem (8 Hrs.)

Variational approach, Galerkin approach, one-dimensional and two-dimensional steady state problems for conduction, convection and radiation, transient problems.

UNIT 6: Application to Fluid Mechanics Problems (10 Hrs.)

In viscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function-vorticity formulation, solution of incompressible and compressible fluid film lubrication problems.

Suggested References/Books:

1. C.S. Desai and T. Kundu, Introductory Finite Element Method, CRC Press, 2001.
2. O.C. Zienkiewicz and R.L. Taylor, The Finite Element Method: Volume 2, 5th ed., Butterworth-Heinemann, 2000.
3. V. Adams and A. Askenazi, Building Better Products with Finite Element Analysis, OnWord Press, 1999.
4. Y.K. Cheung, Finite Element Implementation, Elsevier, 1997.
5. J.M. Champion, J.M. Ensminger, and E.R. Champion, Finite Element Analysis with Personal Computers, Prentice Hall, 1992.
6. I.M. Smith and D.V. Griffiths, Programming the Finite Element Method, 4th ed., Wiley, 2004.
7. K.H. Huebner, D.L. Dewhirst, D.E. Smith, and T.G. Byrom, The Finite Element Method for Engineers, 4th ed., Wiley, 2001.
8. I. Babuska and T. Strouboulis, The Finite Element Method and Its Reliability, Oxford University Press, 2001.

Course title	**ADVANCED DESIGN OF MECHANICAL SYSTEMS**
Course Code	**25C1MEP-103**
Scheme and Credits	**L T P C** **Semester – I** **3 1 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	interpret the product design, its objectives and constraints.
CO 2	apply the concepts of cad, cam and cae and understand the management of industrial design process.
CO 3	classify different types of materials and their selection criteria, working principle and design possibilities.
CO 4	examine the component design and design principles for manufacturability.
CO 5	categorize various assembly processes and guidelines for assembly designs.
CO 6	make use of concept of design for minimizing the environmental issues, global issues, regional and local issues.

UNIT 1: Introduction **(6 Hrs.)**

System design approach for product design, its objectives and constraints, integrated process design for Robust product design, Managing costs.

UNIT 2: Integrated Environment **(8 Hrs.)**

Integrating CAE, CAD, CAM tools, Simulating product performance and manufacturing Processes digitally, Need for industrial design impact, design process investigation of customer needs, conceptualization, refinement, management of the industrial design process, technology driven products, user driven products assessing the quality of industrial design.

UNIT 3: Material Selection **(8 Hrs.)**

Working principle, Materials and Manufacturing Design principles, possible solutions, Materials choice, Influence of materials on form design of welded members, forgings and castings.

UNIT 4: Component Design **(10 Hrs.)**

Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by Separation, simplification by amalgamation, Design for machinability, Redesign of castings based on line considerations, Minimizing core requirements, machined holes, redesign of cast members to obviate cores.

UNIT 5: Design for Manufacture **(10 Hrs.)**

General design principles for manufacturability,: strength and mechanical factors, mechanisms selection, evaluation method, Process capability, Feature tolerances, Geometric tolerances, Assembly limits, Datum features, and Tolerance stacks.

UNIT 6: Design for Assembly **(8 Hrs.)**

Assembly processes, Handling and insertion process, Manual, automatic and robotic assembly, Cost of Assembly, Number of Parts, DFA guidelines.

UNIT 7: Design for the Environment **(10 Hrs.)**

Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines with example / application, Lifecycle assessment, Basic method, Design to minimize material usage, Design for recyclability, Design for Energy efficiency, Design to regulations and standards. Design for sustainability.

Suggested References/Books:

1. K.T. Ulrich and S.D. Eppinger, Product Design and Development, McGraw-Hill International Editions, 1999.
2. G. Boothroyd, Design for Assembly Automation and Product Design, Marcel Dekker, New York, 1980.
3. J.G. Bralla, Design for Manufacture Handbook, McGraw-Hill, 1999.
4. G. Boothroyd, P. Heartz, and W. Nike, Product Design for Manufacture, Marcel Dekker, 1994.
5. J.R. Dickson and C. Poly, Engineering Design and Design for Manufacture: A Structural Approach, Field Stone Publisher, USA, 1995.
6. J. Fixer, Design for the Environment, McGraw-Hill, 1996.
7. A.W. Cliff and T.A. Graedel, Design for the Environment, Prentice Hall, 1995.

Course title	**OPERATIONS MANAGEMENT**
Course Code	**25C1MEP-104**
Scheme and Credits	**L T P C** **Semester – I** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	examine ever growing importance of operations management in any business environment/set up.
CO 2	develop in-depth understanding of resource utilization of an organization.
CO 3	identify the challenges faced by firm's service and manufacturing industry.
CO 4	determine the various aspects of functional management.
CO 5	develop skills to operate competitively in any business scenario.
CO 6	make use of the concepts of inventory and purchasing management

UNIT 1: Introduction **(8 Hrs.)**
Basic concepts of operations and production management, Types of manufacturing systems and their characteristics, scope of operations management.

UNIT 2: Product and Process Design **(8 Hrs.)**
System planning and design, long-range planning, product and process design and technological considerations, MACRO and MICRO process design.

UNIT 3: Demand Forecasting **(10 Hrs.)**
Role of demand forecasting in operations decisions; various demand patterns, qualitative and quantitative techniques of demand forecasting, introduction to standard software used in demand forecasting.

UNIT 4: Production Planning and Scheduling **(12 Hrs.)**
Aggregate production planning, operation scheduling, various scheduling criteria, lot sizing, job shop control; Multi-stage manufacturing systems, their scheduling and management, capacity planning, introduction to standard software used for Production Planning and Scheduling.

UNIT 5: Materials Planning (12 Hrs.)

Details of material requirement planning (MRP), manufacturing resource planning (MRP-II) and enterprise wide resource planning (ERP) with their various techniques, JIT and JIT-II concepts.

UNIT 6: Facilities Planning (10 Hrs.)

Plant design, types and considerations in the plant location, plant layout types, design, evaluation, principles and types of material flow, optimum plant layout.

Suggested References/Books:

1. E.S. Buffa and R.K. Sarin, Modern Production/Operations Management, John Wiley & Sons, 1987.
2. E. Adam Jr. and R.E. Ebert, Production and Operations Management, 6th ed., Pearson Education, 1992.
3. S. Brown, K. Blackmon, P. Cousins, and H. Maylor, Operations Management: Policy, Practice, and Performance Improvement, Butterworth-Heinemann, 2001.
4. K.N. Dervitsiotis, Operations Management, McGraw-Hill, 1981.
5. M.K. Starr, Production and Operations Management, Thomson Business Information, 1996.
6. L.J. Krajewski, L.P. Ritzman, and M.K. Malhotra, Operations Management: Processes and Supply Chains, 9th ed., Pearson Education, 2010.
7. S. Anil Kumar and N. Suresh, Operations Management, New Age International Publishers, 2007.

Course title	**ADVANCED THERMODYNAMICS**
Course Code	**25C1MEP-105**
Scheme and Credits	**L T P C** **Semester – I** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	analyze the availability and thermodynamic property relations
CO 2	apply the chemical thermodynamics and equilibrium to solve industrial problems.
CO 3	solve the problems based on second law analysis of power cycles.
CO 4	determine the thermodynamic analysis of irreversible processes.
CO 5	make use of the concept of thermoelectric energy conversion devices.

UNIT 1: Review of Thermodynamic Laws and Corollaries (16 Hrs.)

Transient Flow Analysis, Second law of thermodynamics, Entropy, Availability and unavailability, Irreversibility, Thermodynamic Potentials, Maxwell's relations, Specific Heat relations, Mayer's relation, Evaluation of Thermodynamic properties of working substance.P.V.T. surface, Equations of state, Real Gas behavior, Vander Waal's equation, Generalised compressibility Factor, Energy properties of Real Gases, Vapour pressure, Clausius– Clapeyron Equation, Throttling, Joule–Thompson coefficient. Non-reactive Mixture of perfect Gases, Governing Laws, Evaluation of properties, Psychrometric properties and psychrometric chart, Air conditioning processes, Cooling Towers, Real Gas mixture.

UNIT 2: Chemical Reactions (14 Hrs.)

Combustion, Combustion Reactions, Enthalpy of Formation, Entropy of Formation, Reference Levels for Tables, Energy of formation, Heat of Reaction, Adiabatic flame Temperature-General problems, Enthalpies, Equilibrium. Chemical Equilibrium of Ideal Gases, Effects of Non-reacting Gases Equilibrium in Multiple Reactions. The VantHoff's Equation. The chemical potential and phase Equilibrium, The Gibbs phase Rule.

UNIT 3: Power Cycles **(8 Hrs.)**

Review, Binary vapour cycle, co-generation and Combined cycles, Second law analysis of cycles, Refrigeration cycles.

UNIT 4: Thermodynamics of Irreversible Processes **(12 Hrs.)**

Introduction, phenomenological laws, Onsager Reciprocity Relation, Applicability of the phenomenological Relations, Heat Flux and Entropy Production, Thermodynamic phenomenon, Thermoelectric circuits.

UNIT 5: Direct Energy Conversion **(10 Hrs.)**

Introduction, Fuel Cells, Thermo-electric energy, Thermo-ionic power generation - Thermodynamic devices, Magneto Hydrodynamic Generators, Photo-voltaic cells.

Suggested References/Books:

1. R.E. Sonntag, C. Borgnakke, and G.J. Van Wylen, Fundamentals of Thermodynamics, 6th ed., Wiley, 2003.
2. D. Doolittle and F. Messe, Thermodynamics, McGraw-Hill, 1984.
3. P.K. Nag, Basic and Applied Thermodynamics, 2nd ed., Tata McGraw-Hill, 2002.
4. M.J. Moran and H.N. Shapiro, Fundamentals of Engineering Thermodynamics, 5th ed., Wiley, 2004.
5. J.P. Holman, Thermodynamics, McGraw-Hill, 1988.
6. H.R. De Groff, Irreversible Thermodynamics, Oxford University Press, 1986.
7. P.L. Dhar, Engineering Thermodynamics, Elsevier, 2008.

Course title	**RESEARCH METHODOLGY**
Course Code	**25C1MEP-201**
Scheme and Credits	**L T P C** **Semester – II** **3 1 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	identify the nature and objective of research and review process.
CO 2	classify and apply sampling techniques using statistical tools.
CO 3	apply various plagiarism tools and understand different statistical tools.
CO 4	design experiment by using Taguchi method and ANOVA.
CO 5	analyze response surface method to process optimization.

UNIT 1: Introduction to Research and Review Process (8 Hrs.)

Nature and objective of research, Research topic, Literature review, Formulation of problem, Research design, Sampling techniques, Data collection, Statistical and sensitive analysis of data, Interpretation of result and report writing.

UNIT 2: Introduction to Design of Experiment (10 Hrs.)

Basic principles, Error analysis in experiments, Classification of experimental designs, Design and analysis of one, 2k and 3k factors experiments, Completely randomized and randomized complete block designs.

UNIT 3: Taguchi Design and ANOVA (12 Hrs.)

Taguchi method, Design of Experiments with the help of orthogonal arrays, Selection of parameters and Taguchi's Robust parameter design, Analysis of Variance, Main effects and interactions, Two-factor and three factors interaction and analysis of variance, Noise factors, Tolerance on control factors. Formation and analysis of Signal-to-Noise Ratio.

UNIT 4: Response Surface Method and Other Approaches to Process Optimize (12 Hrs.)

Introduction to response surface methodology, analysis of second order response surface, blocking in response surface design, the response surface approach to robust design, problem solution.

UNIT 5: Statistical Software **(10 Hrs.)**

Application of Statistical Softwares like SPSS, MS Excel, Mini Tab or MATLAB Software in Data Analysis

UNIT 6: Research Ethics **(8 Hrs.)**

Plagiarism tools, reproducibility and accountability.

Suggested References/Books:

1. A.K. Kaw, E.E. Kalu, and D. Nguyen, Numerical Methods with Applications, University of South Florida, 2008.
2. D.C. Montgomery, Design and Analysis of Experiments, 8th ed., John Wiley & Sons (Asia) Pvt. Ltd., 2012.
3. S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, 4th ed., Tata McGraw-Hill, 2005.
4. S.S. Rao, Engineering Optimization: Theory and Practice, 3rd ed., New Age International, 2000.
5. R.E. Walpole, R.H. Myers, S.L. Myers, and K. Ye, Probability and Statistics for Engineers and Scientists, 7th ed., Pearson Education, 2002.
6. B. Ostle and R.N. Mensing, Statistics in Research, 3rd ed., Oxford & IBH Publishing Co., 1975.
7. C.R. Kothari and G. Garg, Research Methodology: Methods and Techniques, 3rd ed., New Age International Publishers, 2014.

Course title	**TRIBOLOGY**
Course Code	**25C1MEP-202**
Scheme and Credits	**L T P C** **Semester – II** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	identify the basic concepts of tribology, types of contacts, motion and deformations.
CO 2	interpret the friction and wear theories, laws, types and characteristics.
CO 3	examine the importance, types and mechanism of lubrication.
CO 4	make use of the basic concepts of tribology of bearings and industrial applications of tribology.

UNIT 1: Introduction **(10 Hrs.)**

Background, Meaning of tribology, Cost of friction and wear, Types of contacts, Types of motions, Types of deformations, Surface energy and flash temperature theory, Interdisciplinary approach.

UNIT 2: Friction and Wear **(16 Hrs.)**

Topography of engineering surfaces, Material properties influencing friction, Cause/source of friction, Laws of friction, Friction characteristics, Friction of metals, non-metals, lamellar solids, ceramics and polymers, Energy dissipation mechanism, Stick-lip motion, Measurement of friction, Types of wear: abrasive, erosive, cavitation and adhesive wear , Wear mechanism, Theories of wear, Friction effecting wear, Wear of metals and non-metals, ceramics and polymers, Wear measurements in dry and wet environments and Wear equipment.

UNIT 3: Lubrication **(12 Hrs.)**

Importance, Types and mechanism of lubrication, squeeze film, hydro-static, hydrodynamic, elasto-hydrodynamic and plasto-hydrodynamic lubrication, Solution of Reynold's equation in two and three dimensions, Pressure distribution, load carrying capacity and friction forces in oil films, Coefficient of friction in Journal bearing, A brief introduction of solid lubricants and their applications.

UNIT 4: Tribology of Bearings **(10 Hrs.)**

Principle, Operations and Selection Criteria: : hydrodynamic bearing, hydrodynamic journal bearing, hydrostatic bearing, rolling element, ball bearing, roller bearing, needle roller bearing, Design of bearing/journal bearing, Clearance in journal bearing, Minimum film thickness, Sommar-field number, Heat generation and cooling.

UNIT 5: Industrial Applications of Tribology **(12 Hrs.)**

In metalworking: effect of friction, Classification of plastic deformation in rolling, drawing, extrusion, forging, sheet-metal, metal removal and metal finishing, Lube share in metal working process, In Mining: Tools and cutters, Tribology in excavation, loading, haulage and hoisting, In paper and glass fibre industry.

Suggested References/Books:

1. P. Sahoo, Engineering Tribology, PHI Learning Private Limited, 2011.
2. S.K. Srivastava, Tribology in Industries, S. Chand and Company Limited, 2001.
3. B.S. Prabhu, Industrial Tribology: Tribological Failure and Their Analysis, McGraw-Hill Education, 2010.
4. G.W. Stachowiak and A.W. Batchelor, Engineering Tribology, 4th ed., Butterworth-Heinemann, 2013.

Course title	**Modern Manufacturing Processes**
Course Code	**25C1MEP-203**
Scheme and Credits	**L T P C** **Semester – II** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	distinguish between conventional and non-conventional metal cutting processes.
CO 2	apply the principles of mechanics and concept of metal cutting process based on the mechanical energy.
CO 3	interpret the knowledge of thermos-electric energy for the machining of advanced electrically conductive materials.
CO 4	analyze the Electrochemical and Chemical Machining Processes for the modern materials.
CO 5	discuss powder metallurgy technique for producing the products.
CO 6	study basic principles of special manufacturing processes like physical vapor deposition, chemical vapour deposition, thermal metal spraying and Additive manufacturing such as 3-D printing.

UNIT 1: Introduction **(8Hrs.)**

Introduction to different advanced processes, importance and applications of advanced manufacturing processes. Overview: non-conventional machining Processes.

UNIT 2: Mechanical Machining Processes **(10 Hrs.)**

Abrasive jet machining, Ultrasonic machining, Abrasive flow finishing, Magnetic abrasive finishing, Water jet cutting, Abrasive water jet machining process: working principle, theory of material removal, process variables and parametric analysis, process performance, determination of material removal rate and surface finish.

UNIT 3: Thermodynamic Machining Processes **(10 Hrs.)**

Electrical discharge machining (EDM), Electrical discharge grinding (EDG), WEDM, LBM, PAM, EBM: working principle, theory of material removal, process variables and parametric analysis, process performance, determination of material removal rate and surface finish.

UNIT 4: Electrochemical and Chemical Machining Processes (12 Hrs.)

Chemical machining (ChM), ECM, ECG, electrochemical stream drilling (ESD), electrochemical deburring (ECDe), shaped tube electrolytic machining (STEM): working principle, theory of material removal, process variables and parametric analysis, process performance, determination of material removal rate and surface finish.

UNIT 5: Powder Metallurgy (10 Hrs.)

Important characteristics and methods of producing powders, Different techniques to form the miniature product from metal power, Extruding, Isostatic molding, Fibre metal process, Sintering Hot pressing.

UNIT 6: Special Manufacturing Processes (10 Hrs.)

Physical vapor deposition, chemical vapor deposition, thermal metal spraying and Additive manufacturing such as 3-D printing.

Suggested References/Books:

1. G.F. Benedict, Advanced Manufacturing Processes, Marcel Dekker, 1987.
2. P.K. Mishra, Non-Conventional Machining Processes, Narosa Publishing House, 2005.
3. B.H. Amstead, P.F. Ostwald, and M.L. Begeman, Manufacturing Processes, 8th ed., John Wiley & Sons, 1987.
4. N. Cook, Manufacturing Analysis, Butterworth-Heinemann, 1982.
5. P.C. Pandey and H.S. Shan, Modern Machining Processes, Tata McGraw-Hill, 1980.
6. V.K. Jain, Advanced Machining Processes, Allied Publishers, 2002.

Course title	**COMPUTATIONAL FLUID DYNAMIC**
Course Code	**25C1MEP-204**
Scheme and Credits	**L T P C Semester – II** **3 1 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain the basics of computational fluid dynamics and its applications.
CO 2	solve problems using basic flow governing equations.
CO 3	apply partial differential equations to solve numerical problems.
CO 4	analyze engineering problems using the finite difference method.
CO 5	evaluate engineering problems using integral approach, discretization & higher order scheme.
CO 6	design numerical models for turbulent and incompressible viscous flow problems.

UNIT 1 Introduction (8 Hrs.)

Motivation and role of computational fluid dynamics, concept of modeling and simulation. Benefits and limitations of CFD software tools.

UNIT 2: Governing Equations of Fluid Dynamics (8 Hrs.)

Continuity equation, momentum equation, energy equation, various simplifications, dimensionless equations and parameters, convective and conservation forms, incompressible hermos flows, source panel method and vortex panel method.

UNIT 3: Nature of Equations (8 Hrs.)

Classification of PDE, general Thermos of parabolic, elliptic and hyperbolic equations, boundary and initial conditions.

UNIT 4: Finite Difference Method (8 Hrs.)

Discretization, various methods of finite differencing, stability, method of solutions.

UNIT 5: Finite Volume Methods **(8 Hrs.)**

Integral Approach, discretization & Higher order scheme.

UNIT 6: Turbulence Modelling **(10 Hrs.)**

Turbulence, effect of turbulence on N-S equations, different turbulent modelling scheme, Error and uncertainty.

UNIT 7: Incompressible Viscous Flows **(10 Hrs.)**

Stream function-vorticity formulation, solution for pressure, applications to internal flows and boundary layer flows.

Suggested References/Books:

1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, McGraw-Hill, 1998.
2. P.J. Roache, Computational Fluid Dynamics, Hermosa Publishers, 1998.
3. J.F. Wendt, Computational Fluid Dynamics: An Introduction, Springer-Verlag, 2008.
4. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, 2nd ed., Narosa Publishing House, 2008.
5. Y. Jaluria and K.E. Torrance, Computational Heat Transfer, Taylor & Francis, 2003.
6. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor & Francis, 2007.

Course title	**Advanced Welding Technology**
Course Code	**25C1MEP-PE1-01**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe the classification, weldability, defects, and thermal effects in welding.
CO 2	analyze arc welding principles, including arc efficiency and parameter effects.
CO 3	select appropriate welding consumables and power sources for arc welding processes.
CO 4	apply knowledge of metal transfer mechanisms to control melting rates.
CO 5	justify the use of advanced welding techniques for specific applications.

Unit 1: Introduction **(10 Hrs.)**

Classification of welding processes, weldability, welding defects, causes and remedies, weld thermal cycle, metallurgy of fusion welds, solidification mechanism and micro-structural products in weld metal, epitaxial, cellular and dendritic solidification, metallurgical changes in weld metal, phase transformation during cooling of weld metal in carbon and low alloy steel, prediction of microstructures and properties of weld metal. Heat affected zone, re- crystallization and grain growth of HAZ, gas metal reaction, effects of alloying elements on welding of ferrous metals. Welding symbols, safety and hazards in welding.

Unit 2: Welding Arc **(12 Hrs.)**

Arc efficiency, temperature distribution in the arc, arc forces, arc blow, electrical characteristics of an arc, mechanism of arc initiation and maintenance, role of electrode polarity on arc behaviour and arc stability, analysis of the arc; Effects of voltage/current, polarity, welding speed on bead geometry and mechanical properties of weld.

Unit 3: Welding Consumables and Welding Power Sources **(12 Hrs.)**

Classification and selection of welding electrodes and filler rods, Welding fluxes, Role of flux ingredients and shielding gases, Electrode coatings, Arc welding power sources, Basic characteristics of power sources for various arc welding processes, duty cycles, AC, DC welding power source, DC rectifiers, thyristor controlled rectifiers, transistorized units, inverter systems, Arc length regulation in mechanized welding processes.

Unit 4: Metal Transfer and Melting Rate (10 Hrs.)
Mechanism and types of metal transfer, forces affecting metal transfer, modes of metal transfer, metal transfer in various welding processes, effective of polarity on metal transfer and melting rate.

Unit 5: Advanced Welding Processes (16 Hrs.)
Selection of suitable welding process, Theory, principle, technique, advantages, applications, limitations and analysis of advanced welding processes such as Electro-Slag welding, Thermit welding, Ultrasonic welding, Plasma arc welding, Electron Beam welding, Laser Beam welding, Friction welding, Friction stir welding, Forge welding, Diffusion welding, Explosive welding, Atomic hydrogen welding, Microwave welding, Hybrid welding; Resistance welding processes namely Spot, Seam, Projection, Up-set, Flash welding; Other basic welding processes such as Oxy-fuel gas welding, MIG welding, TIG welding, Submerged arc welding and Allied welding processes viz. Brazing, Braze welding, Soldering.

Suggested References/Books:

1. R.S. Parmar, Welding Engineering and Technology, Khanna Publishers, 1997.
2. P.N. Rao, Manufacturing Technology: Foundry, Forming and Welding, Tata McGraw-Hill, 2010.
3. J. Cornu, Advanced Welding Systems, IFS Publications, 1988.
4. R.L. Little, Welding and Welding Technology, Tata McGraw-Hill, 1985.
5. E. Rossi, Welding Technology, McGraw-Hill, 1984.
6. F. Koenigsberger and G. Adaer, Welding Technology, Macmillan, 1971.

Course title	**Automation and Robotics**
Course Code	**25C1MEP-PE1-02**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	define the principles of automation and robotics in industrial applications.
CO 2	classify different types of robotic systems and their components.
CO 3	develop control algorithms for robotic manipulators.
CO 4	analyze the kinematics and dynamics of robotic systems.
CO 5	design automation systems for specific manufacturing processes.

Unit 1: Introduction to Automation **(12 Hrs.)**

Automation production system, Mechanization & Automation, Types of automation, expectations from automation, reasons for automating, basic elements of an automated system, levels of automation, Automation strategies, Mechanical, electrical. Hydraulic and Pneumatic automation devices and controls, Economics of automation.

Unit 2: Manufacturing Automation **(18 Hrs.)**

High Volume Manufacturing automation; classification and type of automatic transfer machines, automation in part handling and feeding, automated flow lines and analysis, design of single model, multi-model and mixed model production lines. Programmable manufacturing automation; CNC machine, programmable robots, Flexible manufacturing automation; single station manufacturing cell, group technology and cellular manufacturing, flexible manufacturing systems, transfer lines and similar automated manufacturing systems, automated assembly systems.

Unit 3: Robot Technology **(16Hrs.)**

Automation and Robots, Robot physical configuration, Classification of Robot Basic, Manipulation of Robot Components, Degree of Freedom and Degree of Motion, Joints and Symbols, Economic and Social Issues, Principles of Robots, Applications. Robot Programming

Methods, Advantages and Disadvantages of Robot, Requirement of a Robot in an Industry, Operational Capabilities level of a Robot, Modular Robot Components, Wrist Mechanism.

Unit 4: Production Support Machines and Systems (14Hrs.)

Industrial robots, automated material handling, transfer devices and feeders – classification, construction details and application of transfer devices and feeders used for job orienting and picking, automated guided vehicles, automated storage and retrieval.

Suggested References/Books:

1. M.P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 3rd ed., Pearson Education, 2011.
2. R.J. Schilling, Fundamentals of Robotics: Analysis and Control, Tata McGraw-Hill, 1996.
3. S.R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw-Hill, 2002.
4. S.R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGraw-Hill, 2001.
5. K.K. Appuu Kuttan, Robotics, I.K. International Publishing House, 2007.
6. S.K. Saha, Introduction to Robotics, McGraw-Hill Education, 2008.

Course title	**ADVANCED MATERIAL CHARACTERIZATION TECHNIQUES**
Course Code	**25C1MEP-PE1-03**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	list the principles of advanced material characterization techniques.
CO 2	interpret data from spectroscopy and microscopy methods.
CO 3	apply X-ray diffraction to analyze material structures.
CO 4	examine material properties using scanning electron microscopy.
CO 5	evaluate the suitability of characterization techniques for specific materials.

Unit 1: Introduction **(8 Hrs.)**
Materials characterization - definition; importance and application. Principles and general methods of compositional, structural and defect characterization.

Unit 2: Diffraction Techniques **(10 Hrs.)**
X-ray diffraction: Introduction, principles, Instrumentation, Specimen preparation, Types of analysis, Data collection for analysis, Applications, Limitations applications and limitations.

Unit 3: Microscopy **(12 Hrs.)**
Optical, electron (TEM & SEM) and electron microprobe analysis, scanning probe methods (STM, AFM, EFM, MFM etc.): Introduction, principles, Instrumentation, Specimen preparation, imaging modes, applications and limitations.

Unit 4: Optical Spectroscopy **(10 Hrs.)**
UV, visible, IR and Raman spectroscopy: Introduction, principles, Instrumentation, Specimen preparation, imaging modes, applications and limitations.

Unit 5: Electron Spectroscopy **(10 Hrs.)**

Auger and photoelectron spectroscopy: Introduction, principles, Instrumentation, Specimen preparation, imaging modes, applications and limitations.

Unit 6: Thermal Methods **(10 Hrs.)**

DTA, TGA, DSC, TMA and DMA: Basic principles, Instrumentation, working principles, Applications, Limitations.

Suggested References/Books:

1. S. Zhang, L. Li, and A. Kumar, Materials Characterization Techniques, CRC Press, 2007.
2. Y. Lang, Materials Characterization, Springer, 2011.
3. D. Briggs and M.P. Seah, Practical Surface Analysis: Auger and X-ray Photoelectron Spectroscopy, Wiley, 1990.
4. P.R. Khangaonkar, An Introduction to Material Characterization, Narosa Publishing House, 2003.
5. ASM International, ASM Handbook Volume 10: Materials Characterization, ASM International, 1993.

Course title	**RAPID PROTOTYPING**
Course Code	**25C1MEP-PE1-04**
Scheme and Credits	**L T P C Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	summarize the principles of rapid prototyping technologies.
CO 2	identify suitable rapid prototyping methods for specific applications.
CO 3	construct prototypes using additive manufacturing techniques.
CO 4	analyze the limitations and advantages of rapid prototyping processes.
CO 5	create optimized designs for rapid prototyping applications.

Unit 1: Introduction to Rapid Prototyping (10 Hrs.)

Classification of Manufacturing Processes, Introduction to Rapid Prototyping, Rapid Prototyping and its Impact, Engineering design process, Product development, Product Prototyping and Product Development, Need of Product Prototyping, Prototype Planning and Management, Product and Prototype Cost Estimation, Prototype Design Methods and tools.

Unit 2: Materials Selections and Product Prototyping (8 Hrs.)

Geometrical Modelling Techniques, Wireframe Modelling, Surface Modelling and solid modelling, Prototyping Materials, Modelling of Material Properties, Modelling and Design of Materials and Structures.

Unit 3: Rapid Prototyping Processes (10 Hrs.)

Rapid Prototyping Overview, Rapid Prototyping Procedure, Liquid-Based RP Processes, Solid-Based RP Processes, Powder-Based RP Processes.

Unit 4: Direct Digital Prototyping and Manufacturing (12 Hrs.)

Solid Models and Prototype Representation, Reverse Engineering for Digital Representation, Prototyping and Manufacturing Using CNC Machining, Fully Automated Digital Prototyping and Manufacturing.

Unit 5: Direct Methods for Rapid Tool Production (12 Hrs.)

Classification of Direct Rapid Tool Methods, Direct ACESTM Injection Moulds, Laminated Object Manufactured (LaM) Tools, DTM Rapid Tool, Sand Form, EOS Direct Tool Process, Direct Metal Tooling using 3Dp. applications of Rapid Prototyping: Functional Models, Pattern for Investment and Vacuum Casting, Medical Model, and Art Models, Engineering Analysis Models

Unit 6: Indirect Methods for Rapid Tool Production (8 Hrs.)

Metal Deposition Tools, RTV Tools, Epoxy Tools, Ceramic Tools, Cast Metal Tools, Investment Casting, Fusible Metallic Core, Sand Casting, Keltool Process.

Suggested References/Books:

1. F.W. Liou, Rapid Prototyping and Engineering Applications, CRC Press, 2007.
2. D.T. Pham and S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer, 2001.
3. K. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Pearson, 2001.

Course title	**ADVANCED METAL CUTTING**
Course Code	**25C1MEP-PE1-05**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	outline the principles of metal cutting processes.
CO 2	select appropriate cutting tools for specific machining operations.
CO 3	model the mechanics of chip formation in metal cutting.
CO 4	inspect tool wear and its impact on machining performance.
CO 5	optimize cutting parameters for improved efficiency and quality.

Unit 1: Introduction **(6 Hrs.)**

Machining fundamentals: work-tool contact, machinable surface, Kinematics of work tool interaction, kinematic elements involved in metal cutting action during different processes, Steriometry of cutting tools: basic shape of cutting tool, tool in hand and system of Tool Nomenclature, standards, Tool Geometry, tool point reference system. Method of master line for rake angle, vector method for rake angle inter relationship.

Unit 2: Oblique Cutting **(6 Hrs.)**

Normal chip reduction coefficient under oblique cutting, True shear angle, effective rake, influx reg on consideration for deformation, Direction of maximum elongation, effect of cutting variables on chip reduction coefficient, Forces system in oblique cutting, effect of wear land on force system. Force system in milling, effect of helix angle, vulf's method, spaan's model for oblique cutting.

Unit 3: Mechanism of Chip Formation **(8 Hrs.)**

Deformation of uncut layer in shear, Methods for frozen chip samples, classification of chips, mechanics of chip curl, factors involved in chip formation analysis, Dynamic shearing strain in chip formation, Effect of nose radius, effect of cutting variables on chip reduction coefficient.

Unit 4: Cutting Forces and Dynamometer **(8 Hrs.)**

Measurement of forces, basic requirement in force measuring techniques, transducers for force measurement, design requirement of dynamometers, different types of force measuring instruments, dynamics of dynamometers, dynamometers for measurement of forces during turning, drilling and milling. Effect of cutting variables on cutting forces. Theoretical determination of cutting forces: Ernst and Merchants upper bond solution, Merchant's second solution and machining constant.

Unit 5: Fundamental Factors Which Effect Tool Forces **(8 Hrs.)**

Correlation of standard mechanized test. (Abuladze-relation), nature of contact and stagnant phenomena, Rates of strains, shear strain and normal strains distribution, Kinetic coefficient of friction analysis, Built up edge phenomena, Effect of cutting variables on BUL and BUE.

Unit 6: Failure of Cutting Tools **(8 Hrs.)**

Tool materials, tool failure, analysis of plastic failure (Form stability criterion), Analyzing failure by brittle fracture, wear of cutting tools, criterion, Flank and creature wear analysis, optimum tool life, tool life equations (Taylor's, woxen etc.) Tool life test, machining optimization predominant types of wear: flank, crater, abrasive, adhesive, diffusion wear models, wear measurements techniques, Theory of tool wear, oxidative, Mathematical modeling for wear, Test of machinability and influence of metallurgy on machinability.

Unit 7: Economics of Machining **(6 Hrs.)**

Economic tool life; Gilbert's Model, Optimal cutting speed for Maximum production; Maximum profit cutting speed, objective criteria for optimization, selection of optimum cutting parameters under various restrictive conditions, Brewer and Rueda's optimization for maximum power constraint and maximum feed, Bjrcke's Generalized Model, Sensitivity analysis in Machining economics, Economy based on Non Taylorian Tool life laws; Economics of multipass cutting.

Unit 8: Advance Metal Machining **(4 Hrs.)**

Composite cutting, ceramic and super alloys cutting, cutting tool selection, process parameters and geometry effect on machinability during cutting of composite, ceramics and super alloys.

Unit 9: Surface Integrity and Finishes **(6 Hrs.)**

Surface metallurgy and topography, factors affecting the surface quality, the numerical assessment of the machined surface, ISO recommendation for assessment of machined surface, super finishing processes, and kinematics of super finishing. Mechanics of lapping and honing, three-body abrasion.

Suggested References/Books:

1. A. Bhattacharyya, Metal Cutting Theory and Practice, Central Book Publishing House, Calcutta, 1983.
2. M. Shaw, Metal Cutting, Oxford University Press, 2005.
3. A. Ghosh and A.K. Mallik, Manufacturing Science, 2nd ed., Affiliated East-West Press, New Delhi, 2002.

Course title	**ADVANCED CASTING PROCESSES**
Course Code	**25C1MEP-PE1-06**
Scheme and Credits	**L T P C Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe the properties of moulding sands and pattern materials.
CO 2	analyze solidification processes in metals and alloys.
CO 3	design gate and riser systems for casting processes.
CO 4	apply advanced casting techniques like investment and die-casting.
CO 5	assess casting defects and propose remedies for quality control.

Unit 1: Introduction (12 Hrs.)

Ferrous and non-ferrous materials and their properties, Pattern materials, types and allowances, Characteristics, Ingredients and additives of moulding sand, core sands, Structure of silica and different types of clays, bonding mechanism of silica-water-clay system, Swelling of clays, sintering adhesion and colloidal clay, silica grain shape and size distribution, standard permeability A.F.S. clay, Special sand additives

Unit 2: Solidification of Metals (14 Hrs.)

Nucleation and growth in metals and alloys, Free energy concept, Critical radius of nucleus, Segregation, Progressive and directional solidification, Constitutional super cooling, Columnar equi-axed and dendritic structures, Freezing of alloys, Centreline feeding resistance, Rate and time of solidification, mould constant, Fluidity of metals, Volumes redistribution, Solidification simulation, Analysis of the process.

Unit 3: Gate and Riser Design (14 Hrs.)

Various elements of gating system, gating-system design for ferrous and non-ferrous materials, Top, bottom and inside gating, Different methods for riser design, Riser design shape, size and placement, Effect of appendages on risering, Effective feeding distances for simple and complex shapes, Use of chills, Aspiration of gases, Directional solidification stresses in castings, Metal mould reactions, Expansion scale and metal penetration, Analysis of the process

Unit 4: Advanced Casting Processes (12 Hrs.)

Investment casting, Shell mould casting, Full mould casting, Vacuum casting, Die casting, Permanent mould casting, Continuous casting, Centrifugal casting, Squeeze casting, Slush casting

Unit 5: Casting Defects, Heat-Treatment of Castings and Moulding Sand Testing (8 Hrs.)

Casting defects, causes and remedies; Heat treatment of steel, iron and stainless-steel castings; Moulding sand testing and control, Repair and salvage of castings, Quality control in foundries.

Suggested References/Books:

1. F.A. Flinn, Fundamentals of Metal Casting, Addison-Wesley, 1962.
2. P.N. Rao, Manufacturing Technology: Foundry, Forming and Welding, Tata McGraw-Hill, 2010.
3. R.C. Heine, C.R. Loper Jr., and P.C. Rosenthal, Principles of Metal Casting, 2nd ed., McGraw-Hill, 1967.
4. S. Salman and T. Simans, Foundry Practice, Isaac Pitman & Sons, 1986.
5. R.W. Heine, Principles of Metal Casting Processes, McGraw-Hill, 1960.
6. P.L. Jain, Principles of Foundry Technology, Tata McGraw-Hill, 1991.

Course title	**MAINTENANCE AND RELIABILITY ENGINEERING**
Course Code	**25C1MEP-PE1-07**
Scheme and Credits	**L T P C Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain the concepts of maintenance engineering and terotechnology.
CO 2	plan maintenance schedules and control processes.
CO 3	analyze safety hazards and housekeeping procedures in maintenance.
CO 4	utilize reliability concepts for failure analysis.
CO 5	evaluate methods for reliability prediction and system dependability.

Unit 1: Introduction **(8 Hrs.)**
Concept of maintenance and terotechnology, objective and importance of maintenance engineering, functions and classification, types of maintenance: corrective, renovative, preventive, breakdown, planned, proactive, predictive etc.

Unit 2: Maintenance Planning and Control **(10 Hrs.)**
Basic requirements of maintenance systems, responsibilities of maintenance engineering department, control and coordination in maintenance, Maintenance planning, Daily/monthly/annually maintenance schedule, Format/preparation of equipment history, failure analysis report, daily maintenance progress report, Total productive maintenance (TPM)

Unit 3: Safety and House Keeping In Maintenance **(10 Hrs.)**
Hazards: classification, important factors of hazards and causes of accidents, categories of hazards and measurement, procedure of minimizing hazard, different safety devices, their applications and safety checklist. Factors governing housekeeping, housekeeping maintenance and inspection.

Unit 4: Reliability and Hazard Rates (12 Hrs.)

Reliability, maintainability, failure, hazard rate concept, availability, Reliability structure and optimum design configuration of series, parallel, combination of series and parallel, redundancy structure. Mean time to failure (MTTF), mean time between failures (MTBF), mean time to repair (MTTR). Breakdown time distribution. 5-WHY concept for root cause.

Unit 5: Reliability Prediction and Analysis (12 Hrs.)

Quantitative estimation of reliability: Kuder-Richardson formula, Statistical estimation of reliability. ReliaSoft's Lambda hybrid automated reliability predictor. Reliability prediction based on exponential distribution, system reliability analysis – block diagram method, fault tree and success tree methods, event tree method, failure model, failure mechanism.

Unit 6: Reliability Design (8 Hrs.)

Design for reliability, design process, assessment methodology, reliability allocation, reliability improvement, selection of components to improve system reliability.

Suggested References/Books:

1. O.P. Khanna, Industrial Engineering and Management, Dhanpat Rai & Sons, 1994.
2. A. Manna, A Textbook of Reliability and Maintenance Engineering, I.K. International Publishing House, 2010.
3. K. Kelly, Maintenance Planning and Control, Butterworths, 1984.
4. G. Krishnan, Maintenance and Spare Parts Management, Prentice Hall, 1991.
5. A.K. Gupta, Reliability Engineering and Technology, Macmillan India Ltd., 1996.
6. E.E. Lewis, Introduction to Reliability Engineering, John Wiley & Sons, 1996.
7. L.S. Srinath, Reliability Engineering, East-West Press, 1991.

Course title	**SUPPLY CHAIN MANAGEMENT**
Course Code	**25C1MEP-PE1-08**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain the role of supply chain drivers and obstacles in achieving strategic fit.
CO 2	analyze supply chain performance metrics and process cycles across different stages.
CO 3	apply economies of scale principles to optimize cycle and safety inventory levels.
CO 4	design transportation networks considering trade-offs and performance characteristics.
CO 5	evaluate logistics strategies to enhance competitive advantage and profitability.
CO 6	develop benchmarking and coordination strategies to mitigate the Bullwhip effect.

Unit 1: Supply Chain Drivers and Obstacles (6 Hrs.)
Four drivers of supply chain inventory transportation, facilities, and information, a framework for structuring drivers, role of each driver in supply chain, obstacles to achieve strategic fit.

Unit 2: Supply Chain Performance (10 Hrs.)
Objectives of supply chain, stages of supply chain, supply chain process cycles, customer order cycle, replenishment cycle, manufacturing cycle, procurement cycle, push/pull view of supply chain processes, importance of supply chain flows, examples of supply chain, supply chain strategies, achieving strategic fit, product life cycle, the minimize local cost view, the minimize functional cost view, the maximize company profit view, the maximize supply chain surplus view.

Unit 3: Managing Economies of Scale in a Supply Chain (8 Hrs.)
Role of cycle inventory in a supply chain, economies of scale to exploit fixed costs, economies of scale to exploit quantity discounts, short term discounting, estimating cycle inventory related costs, determining appropriate level of safety inventory.

Unit 4: Transportation in a Supply Chain (10 Hrs.)
Facilities affecting transportation decisions, modes of transportation and their performance characteristics, design options for a transport network, trade-offs in transportation decisiontailored

transportation, routing and scheduling in transportation, making transportation decisions in practice.

Unit 5: Logistics and Competitive Strategy (8 Hrs.)
Competitive advantage, gaining competitive advantage, advantage through logistics, mission of logistics management, supply chain and competitive performance, changing logistics environment.

Unit 6: Measuring Logistics Costs and Performance (6 Hrs.)
The concept of total cost analysis, principles of logistics costing, logistics and the bottom line, logistics and shareholder value, customer profitability analysis, cost drivers and activity based costing.

Unit 7: Benchmarking the Supply Chain (6 Hrs.)
Benchmarking the logistics process, mapping supply chain processes, supplier and distributor benchmarking, identifying logistics performance indicators, setting benchmarking priorities.

Unit 8: Coordination in a Supply Chain (6 Hrs.)
Lack of supply chain coordination and the Bullwhip effect, effect of lack of coordination on performance, obstacles to coordination, managerial levers to achieve coordination, achieving coordination in practice.

Suggested References/Books:

1. M. Christopher, Logistics and Supply Chain Management, Pearson Education Asia, 2002.
2. P. Meindl, Supply Chain Management: Strategy, Planning, and Operation, Pearson Education Asia, 2003.
3. K.K. Kapoor and P. Kansal, Marketing Logistics: A Supply Chain Approach, Pearson Education Asia, 2002.
4. A. Muhlemann, J. Oakland, and K. Lockyer, Production and Operation Management, Macmillan India Publications, 2000.
5. K. Aswathappa and K.S. Bhat, Production and Operations Management, Himalaya Publishing House, Mumbai, 2000.
6. R. Panneerselvan, Production and Operations Management, Prentice Hall of India, Delhi, 2005.
7. S.G. Deshmukh, Essentials of Supply Chain Management, Wiley India, 2010.

Course title	**PRODUCT DESIGN AND DEVELOPMENT**
Course Code	**25C1MEP-PE1-09**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	identify economic and production factors in product design.
CO 2	apply engineering principles to develop product designs.
CO 3	analyze modern product design approaches like concurrent design.
CO 4	create innovative product designs using problem-solving techniques.

Unit 1: Creative Thinking and Organizing For Product Innovation (18 Hrs.)

The product design function, Locating ideas for new products, selecting the right product, Qualifications of the product design engineer, Creative thinking, Curiosity and imagination, Ideas generate ideas, Taking time to think, Using a systematic producer for product innovation, Setting responsibilities for new product development, Structural units for new product development, Functions of the new product development unit, Opportunities for the product design engineer.

Unit 2: Criteria for Product Success (16 Hrs.)

Areas to be studied preparatory to design, Principles of values and laws of appearance, Incorporating quality and reliability into the design, Man-machine consideration, Designing for case of maintenance.

Unit 3: Cost and Product Development (12 Hrs.)

Source of funds for development cost product costs, Estimating the product cost, Kinds of cost procedures, Cost reduction.

Unit 4: Integrated Approach to Product Development (14 Hrs.)

Diffusion of innovation. Generation, screening and development of new product ideas, Product life cycle and new product development, Economic analysis-evaluation of new product ideas/concepts, Value analysis, Test marketing of new product launch.

Suggested References/Books:

1. R.G. Chitale and R.C. Gupta, Product Design and Manufacturing, Prentice Hall, 1997.
2. S. Bagchi, Taguchi Methods Explained: Practical Steps to Robust Design, Prentice Hall, 1997.
3. B.R. Nible and R.A. Draper, Product Design and Process Engineering, McGraw-Hill, 1998.
4. G.L. Urban and J.R. Hauser, Design and Marketing of New Products, Prentice Hall, 1980.
5. P. Kotler and G. Phillips, Marketing Management, Prentice Hall, 1990.
6. R. Mascarenhas, New Product Development, Oxford University Press, 1987.
7. O.P. Kaushal, Product Management, Lalvani Publishing House, 1967.
8. B. Burns and A. Stalk Jr., The Management of Innovation, Tasstoch Publishing, 1961.

Course title	**ENGINEERING DESIGN OPTIMIZATION**
Course Code	**25C1MEP-PE1-10**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	define optimization techniques in engineering design.
CO 2	formulate optimization problems using mathematical models.
CO 3	analyze optimization methods like gradient-based techniques.
CO 4	apply advanced optimization algorithms like genetic algorithms.
CO 5	evaluate the effectiveness of optimization strategies in design.

Unit 1: Introduction to Optimization **(8 Hrs.)**

Terminology; Optimization problem statement, Iterative optimization, Existence and uniqueness of solutions, Necessary and sufficient conditions.

Unit 2: Unconstrained Optimization Techniques **(14 Hrs.)**

General principles of optimization; Problem formulation & their classifications; Single variable and multivariable optimization; Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods; Interpolation methods.

Unit 3: Constrained Optimization Techniques **(10 Hrs.)**

Optimization with equality and inequality constraints; Direct methods; Indirect methods using penalty functions, Lagrange multipliers; Geometric programming.

Unit 4: Advanced Optimization Techniques **(12 Hrs.)**

Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization.

Unit 5: Application in Design **(16 Hrs.)**

Structural applications – Design of simple truss members; Design applications – Design of simple axial, transverse loaded members for minimum cost, weight; Design of shafts and torsionally loaded members, Design of springs. Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms; Optimum design of simple linkage mechanisms.

Suggested References/Books:

1. S. S. Rao, Engineering Optimization – Theory & Practice, New Age International (P) Ltd., New Delhi, 2000.
2. C. Ray Johnson, Optimum Design of Mechanical Elements, Wiley, John & Sons, 1990.
3. K. Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India Pvt. Ltd., 1995.
4. D.E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, New York, 1989.

Course title	**ADVANCED VIBRATION ENGINEERING**
Course Code	**25C1MEP-PE1-11**
Scheme and Credits	**L T P C** **4 0 0 4** **Semester – II/III**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain vibration principles in multi-degree of freedom systems.
CO 2	solve vibration problems using numerical methods like Rayleigh-Ritz.
CO 3	analyze continuous system vibrations using Duhamel's integral.
CO 4	design vibration control systems for machines.
CO 5	assess random and non-linear vibration behaviors.

UNIT 1: Introduction (6 Hrs.)

Viscous damping, Logarithmic decrement, Torsional system with viscous damping, Free vibration, Coulomb damping, Hysteretic damping, Equivalent viscous damping. Introduction to Coupled Vibrations. Hamiltons Principle, Galarkin Method, Shape Functions.

UNIT 2: Two Degree of Freedom System (8 Hrs.)

Introduction to free vibrations of undamped system, Torsional system, Coordinates coupling and principal coordinates, Damped free vibrations, Forced vibration of undamped system, Forced vibration with damping, Dynamic vibration absorber, Orthogonality principle.

UNIT 3: Multi Degree of Freedom System (12 Hrs.)

Equation of motion, method of influence coeffiecents, Lagrange's equation, Mode shape orthogonality, Rayleigh-Proportional damping, General Viscous damping, Harmonic excitations, Laplace transform solution, Model analysis for undamped and damped systems. Simple example on vibration in Plates and Shells, Dean and Plass Method.

UNIT 4: Numerical Techniques to Find Natural Frequencies (8 Hrs.)

Rayleigh's method, Holzer's method, Matrix iteration method, Cholesky decomposition, Jacob diagonalization method, Inverse simultaneous and subspace iteration method.

UNIT 5: Vibration Analysis of Continuous System (8 Hrs.)

Transverse vibration of strings, Longitudinal vibration of rods, Torsional vibration of shaft and beams, Effects of the rotary inertia and shear deformation, Approximate solution methods: Rayleigh's, Rayleigh-Ritz, Galerken's methods. Collocation Method, Transfer Matrix.

UNIT 6: Transient and Random Vibration Analysis (8 Hrs.)

Response to impulse excitation, Arbitary forcing function, Base excitation, Laplace transformation method, Response to random inputs, Shock response spectrum, Non Linear Vibrations, Numerical integration methods in vibration analysis : Problem and Case Study.

UNIT 7: Finite Element Method Applied to Vibrations (10 Hrs.)

Equations of motions of complete system of finite elements application in the domain of vibration, Incorporation of boundary conditions, Consistent and lumped mass matrices for bar, beam etc. Model reduction problem. Holzers Method, Stodola Method, Matrix Iteration and Inversion Method.

Suggested References/Books:

1. J. Srinivas and V. Dukkipati Rao, A Textbook of Mechanical Vibration, Prentice Hall of India Pvt. Ltd., New Delhi, 2007.
2. P. Srinivasan, Nonlinear Mechanical Vibration, New Age Publishers, 1994.
3. L. Meirovitch, Elements of Vibration Analysis, McGraw-Hill, 1986.
4. D. J. Inman, Engineering Vibration, 3rd ed., Prentice Hall, 2007.
5. R. A. Anderson, Fundamentals of Vibration, McGraw-Hill, 2003.
6. S. Timoshenko, D.H. Young, and W. Weaver, Vibration Problems in Engineering, 4th ed., Wiley, 1974

Course title	**MECHATRONICS**
Course Code	**25C1MEP-PE1-12**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe the components of mechatronic systems.
CO 2	develop control systems for mechatronic applications.
CO 3	analyze sensor and actuator integration in mechatronics.
CO 4	design mechatronic systems for automation tasks.
CO 5	evaluate the performance of mechatronic systems.

UNIT 1: Introduction **(6 Hrs.)**

Basics fundamentals, Definition and concept, Need of Mechatronics in mechanical Engineering, Elements of Mechatronics system, Mechatronics Design process, Systems, Measurement Systems, Control systems, Microprocessor based controllers, Advantages and Disadvantages of mechatronics system.

UNIT 2: Dynamic Models **(6 Hrs.)**

Block diagrams, Laplace Transformation, Transfer Function, State Space Models, Control actions, linear system analysis.

UNIT 3: Fluid Power Control **(10 Hrs.)**

Fluid power control elements, Standard graphical symbols, Construction and performance of fluid power generators, hydraulic and pneumatic cylinders, construction design and mountings, hydraulic and pneumatic valves for pressure, flow and direction control, servo valves and simple servo system with mechanical feedback, governing differential equation and its solution for step position input, basic hydraulic and pneumatic circuits. Pneumatic logic circuit design for a given time-displacement diagram.

UNIT 4: Sensors and Transducers (8 Hrs.)

Types of Transducers, Characteristic Parameters used in transducers, Displacement, Position, Proximity, Velocity, Motion, Force, Acceleration, Light and Piezoelectric Sensors, Selection of sensors.

UNIT 5: Actuating Devices and Process Controllers (6 Hrs.)

D C Motors, Permanent magnet stepper motors, Piezo-electric actuators, Controller Principles, Two Position, Proportional, Derivative, Integral, PD and PID Controller.

UNIT 6: System and Frequency Response (8 Hrs.)

Static Response, Poles, Zeros and Stability, Types of Responses, (Transient, Steady-state, Total, Frequency): Experimental determination of frequency response, Polar plots (Nyquist diagrams), Gain margin and Phase margin, Bode diagrams, Lead and lag compensators.

UNIT 7: Signal Conditioning, Digital Electronics and Systems (8 Hrs.)

Signal Conditioning, The Operational amplifier, Noise Reduction, Current to Voltage and Voltage to Current, Voltage to Frequency and Frequency to Voltage Converters, Analogue to digital, Digital to analogue conversion, Sampling theorem, , Types of Digital filters, Digital logic control, Microprocessors and Microcontrollers, Introduction to PLC.

UNIT 8: Mechatronics System (8 Hrs.)

Traditional and Mechatronics designs, Possible mechatronics design solutions, Case studies of Mechatronic systems, Application of mechatronics in manufacturing and automation (Machine tool and Automobile).

Suggested References/Books:

1. K.P. Ramachandran, G.K. Vijayaraghavan, and M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley, 1st ed., 2011.
2. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 3rd ed., Pearson Education, 2007.
3. D. Shetty and R.A. Kolk, Mechatronics System Design, 2nd ed., Cengage Learning, 2012.
4. S.R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGraw-Hill Education, 2005.

Course title	**DYNAMICS OF ROTATING MACHINES**
Course Code	**25C1MEP-PE1-13**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	outline the dynamics and operating principles of rotating machinery.
CO 2	model rotor and shaft behavior considering mass, stiffness, and damping.
CO 3	analyze critical speeds and whirl phenomena in rotating systems.
CO 4	design effective balancing techniques for rotating machinery.
CO 5	assess vibration control methods for improved machine performance.

UNIT 1: Introduction **(12Hrs.)**

Rotating machine components, Aspects of rotating machine behaviour, Co-ordinate systems, Steady state rotor motion, Elliptical motion, Single degree of freedom systems, Free and forced vibrations. The two degrees of freedom rotor system, Geared systems, Translational motion, Natural frequencies and Natural modes, Steady state response to unbalance, Linear rotor dynamics, Non-linear rotor dynamics, Non-stationary rotor dynamics.

UNIT 2: Torsional and Axial Dynamics **(10 Hrs.)**

Modeling of rotating machinery shafting, Multi degree of freedom systems, Determination of natural frequencies and mode shapes, Branched systems, Numerical methods for fundamental frequency, Torsional critical speeds, Axial vibration.

UNIT 3: Rigid Rotor Dynamics and Critical Speed **(14 Hrs.)**

Rigid disk equation - Rigid rotor dynamics, Rigid rotor and flexible rotor, The gyroscopic effect on rotor dynamics, Whirling of an unbalanced simple elastic rotor, Unbalance response, Orbital Analysis and Cascade Plots, Simple shafts with several disks, Effect of axial stiffness, Determination of bending critical speeds, Campbell diagram.

UNIT 4: Influence of Bearings on Rotor Vibrations (12 Hrs.)

Support stiffness on critical speeds- Stiffness and damping coefficients of journal bearings, Computation and measurements of journal bearing coefficients, Mechanics of Hydro dynamic Instability, Half frequency whirl and Resonance whip, Design configurations of stable journal bearings.

UNIT 5: Balancing of Rotors (12 Hrs.)

Single plane balancing, Multi-plane balancing, Balancing of rigid rotors, Balancing of flexible rotors, Influence coefficient and modal balancing techniques for flexible rotors.

Suggested References/Books:

1. J.S. Rao, Rotor Dynamics, New Age International Publishers, New Delhi, 2000.
2. S. Timoshenko, D.H. Young, and W. Weaver, Vibration Problems in Engineering, 4th ed., John Wiley & Sons, 1974.
3. W.J. Chen and J.E. Gunter, Introduction to Dynamics of Rotor–Bearing Systems, Trafford Publishing Ltd., 2000.

Course title	**EXPERIMENTAL STRESS ANALYSIS**
Course Code	**25C1MEP-PE1-14**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	study various experimental stress analysis techniques.
CO 2	apply strain gauge measurements in stress analysis.
CO 3	analyze photoelasticity methods for stress distribution.
CO 4	develop experimental setups for stress analysis.
CO 5	evaluate the accuracy of experimental stress analysis methods.

UNIT 1: Principles of Experimental Approach (6 Hrs.)

Introduction to ESA, Advantages of ESA techniques, Necessity of various ESA methods, methodology of problem solving by ESA Strategy.

UNIT 2: Strain Measurement Techniques (8 Hrs.)

Introduction to strain measurement: Review of Stress, Strain, and Hooke's Law: Definition of Stress and Strain Tensors, Constitutive Models Strain Gages: Properties of Strain gauge Systems, Types Resistance Strain gauges: Construction, Mounting methods, Gage Sensitivity, Strain Gage Circuits: Wheatstone bridge, constant current circuits Calibration of circuits, Bridge Sensitivity and Measurement Corrections, Thermal Corrections Gage Factor, Performance Characteristics, Environmental effects. Recording Instruments: Static and Dynamic Recording, Digital Data Acquisition Systems, Telemetry Systems Strategy.

UNIT 3: Strain Analysis Methods (8 Hrs.)

Three element rectangular strain rosette, correction, stress gauges, over-deterministic methods for strain analysis, residual stress determination Applications: Application of strain gauges for measurement of load, temperature, pressure, vibration, stress and strain etc.

UNIT 4: Optical Methods of Stress Analysis (6 Hrs.)

Basic of Optics, Optical Instrumentation Moire Fringe technique-theory and experimental procedures, Fractional fringe measurement -Tardy's Method , Babinet Soleil Method. Strategy.

UNIT 5: Theory of Photoelasticity, Polariscope (12 Hrs.)

Plane polariscope, Circular polariscope,Different Arrangements photoelastic photography, Photoelastic materials-properties, selection, casting methods, caliberation. Analysis Techniques-Determination of direction of Principal stresses at given point, Determination of exact fringe order N and the principal stress Separation methodsMethod based on Hooke's Law, Electrical analogy method, Oblique incidence method,Shear difference method, Scaling model results to prototype. Application of photoelasticity to 2-D and 3-D Stress analysis Strategy

UNIT 6: Optical Methods for Determining Fracture Parameters (6 Hrs.)

Irwins methods, application. of moiré and isopachic fringe pattern to determine stress intensity factor, mixed mode intensity factors Strategy.

UNIT 7: Coating Techniques (6 Hrs.)

Bifringent coating- stress-optic and strain-optic relation, sensitivity and coating materials, fringe order determination. Brittle coating technique. Strategy

UNIT 8: Holography (8 Hrs.)

Plane and spherical waves - coherence - holographic setup - Interferometry - Displacement measurement -obtaining Isopachics, Strategy.

Suggested References/Books:

1. S. Singh, Experimental Stress Analysis, Khanna Publishers, New Delhi, 1996.
2. J.W. Dalley and W.F. Riley, Experimental Stress Analysis, McGraw-Hill Book Company, New York, 1991.
3. L.S. Srinath et al., Experimental Stress Analysis, Tata McGraw-Hill, New Delhi, 1984.
4. R.S. Sirohi and H.C. Radhakrishna, Mechanical Measurements, New Age International (P) Ltd., 1997.
5. F.K. Garas, J.L. Clarke, and G.S.T. Armer, Structural Assessment, Butterworths, London, 1987.
6. R.J. Dove and W.C. Adams, Experimental Stress Analysis and Motion Measurement, Prentice Hall of India, 1965.

Course title	**SUSTAINABLE DESIGN AND MANUFACTURING**
Course Code	**25C1MEP-PE1-15**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain the principles of sustainable development.
CO 2	apply Life Cycle Assessment in product design.
CO 3	analyze Environmental Impact Assessment methods.
CO 4	design eco-friendly products using sustainable methods.
CO 5	assess sustainability using environmental and economic indicators.

UNIT 1: Concepts of Sustainability and Sustainable Development (14 Hrs.)

Need for sustainable development - Components of sustainability- Social, Economic, Environmental dimensions - Linkages between technology and sustainability - Sustainable Manufacturing –Scope, Need, design, practice, matrices and Benefits, Sustainable business models, Waste minimization

UNIT 2: Tools and Techniques of Sustainable Manufacturing (12 Hrs.)

Environmental Conscious Quality Function Deployment, Life cycle management and assessment, Design for Environment, R3 and R6 cycles, Design for Disassembly -Sustainable Product Development – Various Phases.

UNIT 3: EIA Methods (10 Hrs.)

CML, EI 95 and 99, ISO 14001 EMS and PAS 2050 standards, Environmental Impact parameters - Interactions between energy and technology and their implications for environment and sustainable development.

UNIT 4: Design for Recycling (12 Hrs.)

Eco friendly product design methods – Methods to infuse sustainability in early product design phases – Multi-Criteria Decision Making in Sustainability.

UNIT 5: Frameworks for Measuring Sustainability (12 Hrs.)

Indicators of sustainability – Environmental, Economic, Societal and Business indicators - Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment– Corporate Social Responsibility.

Suggested References/Books:

1. G. Atkinson, S. Dietz, and E. Neumayer, Handbook of Sustainable Manufacturing, Edward Elgar Publishing Limited, 2012.
2. D. Rodick, Industrial Development for the 21st Century: Sustainable Development Perspectives, United Nations, New York, 1997.
3. P.P. Rogers, K.F. Jalal, and J.A. Boyd, An Introduction to Sustainable Development, Earthscan, London, 2008.
4. P. Lawn, Sustainable Development Indicators in Ecological Economics, Edward Elgar Publishing Limited, 2005.
5. S. Asefa, The Economics of Sustainable Development, W.E. Upjohn Institute for Employment Research, 2004.

Course title	**VIBRATION AND NOISE CONTROL**
Course Code	**25C1MEP-PE1-16**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe vibration and noise control techniques.
CO 2	solve multi-degree of freedom vibration problems.
CO 3	analyze continuous system vibrations using numerical methods.
CO 4	design vibration isolation and damping systems.
CO 5	evaluate noise control methods using sound measurement tools.
CO 6	apply modal analysis for vibration control.

UNIT 1: Multi Degree Freedom System (12 Hrs.)

Free Vibration equation of motion. Influence Coefficient (i) Stiffness Coefficient (ii) Flexibility Coefficient. Generalized coordinates, and Coordinate couplings. Langranges Equations Matrix Method Eigen Values Eigen Vector problems. Modal Analysis .Forced Vibrations of undamped system and modal analysis.

UNIT 2: Multi Degree System Numerical Methods (8 Hrs.)

(i)Rayleigh`s Method, (ii)Rayleigh-Ritz Method (iii) Holzer`s Method (iv)Methods of Matrix iterations (v) Transfer Matrix Method and Impulse response and frequency response functions.

UNIT 3: Continuous System and Transient Vibrations (10 Hrs.)

Vibrations of String, Bars, Shafts and beams, free and forced vibration of continuous systems. Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel’s) integral, impulse response functions.

UNIT 4: Vibration Control and Measurement (10 Hrs.)

Balancing of rotating machine, In-situ balancing of rotors, control of natural frequency introduction of damping, vibration isolation & vibration absorbers. FFT analyzer, vibration exciters, signal analysis. Time domain & Frequency domain analysis of signals. Experimental modal analysis, Machine Conditioning and Monitoring, fault diagnosis.

UNIT 5: Random and Non-Linear Vibrations (10 Hrs.)

Expected values auto and cross correlation function, Spectral density, response of linear systems, analysis of narrow band systems. Systems with non-linear elastic properties, free vibrations of system with non-linear elasticity and damping, phase-plane technique, Duffing's equation, jump phenomenon, Limit cycle, perturbation method.

UNIT 6: Noise and its Measurement (10 Hrs.)

Sound waves, governing equation its propagation**,** Fundamentals of Noise, Decibel, Sound Pressure level, Sound Intensity, Sound fields, reflection, absorption and transmission .Noise measurement, Sound meter, Allowed exposure levels and time limit by B.I.S., Octave Band analysis of sound, Fundamentals of Noise control, source control, path control, enclosures, noise absorbers, noise control at receiver.

Suggested References/Books:

1. W.T. Thomson, Theory of Vibrations with Applications, CBS Publishers, Delhi, 1981.
2. S.S. Rao, Mechanical Vibrations, Addison-Wesley Publishing Company, 1995.
3. L. Meirovitch, Fundamentals of Vibration, McGraw-Hill International Edition, 1986.
4. A.K. Mallik, Principles of Vibration Control, Affiliated East-West Press, 2000.
5. A.H. Church, Mechanical Vibrations, John Wiley & Sons, 1982.
6. J.P. Den Hartog, Mechanical Vibrations, McGraw-Hill, 1985.
7. S. Srinivasan, Mechanical Vibration Analysis, McGraw-Hill, 1991.
8. K. Pujara, Vibration and Noise for Engineers, Dhanpat Rai & Sons, 2002.

Course title	**COMPOSITE MATERIALS**
Course Code	**25C1MEP-PE1-17**
Scheme and Credits	**L T P C Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	study composite materials and their applications.
CO 2	select matrix and reinforcement combinations for composites.
CO 3	analyze the properties of composite materials.
CO 4	study the various processing techniques, properties and applications of composites.

UNIT 1: Introduction of Composite (6 Hrs.)
Composites and their classification, Particulate composites, Hybrid composites, Long aligned fiber composites.

UNIT 2: Introduction of Polymers (10 Hrs.)
Classification of Polymers – Properties of Thermo plastics – Properties of Thermosetting Plastics – Applications – Merits and Demerits

UNIT 3: Reinforcements (10 Hrs.)
Glass fibers, Boron fibers, Carbon fibers, Organic fibers, Ceramic fibers, Nonoxide fibers, Comparison of different types of fibers.

UNIT 4: Matrix Material (10 Hrs.)
Polymers, metals, Ceramic matrix materials and their properties

UNIT 5: Processing of Composites (14 Hrs.)
Hand lay-up, Pre peg processing, Press molding, Vacuum molding, Filament winding, extrusion, Pultrusion, liquid metal infiltration process, Diffusion bonding and powder metallurgy methods, joining of composites, Basic properties of GRP, CFRP, Al-B, Casting and Particulate composites.

UNIT 6: Properties and Applications **(10 Hrs.)**

Modulus, Strength, Thermal characteristics, Aging, Fatigue, Creep, Transport properties, Matrix connectivity, Aerospace application, Structural, Defense biomedical application, Machine tools, Automobiles applications.

Suggested References/Books:

1. K.K. Chawla, Composite Materials, Springer, 2008.
2. B. Harris, Engineering Composite Materials, Maney Publishing, 1998.
3. W.D. Callister Jr., Materials Science & Engineering: An Introduction, 7th ed., Wiley & Sons, 2007.
4. C. Rauwendaal, Polymer Extrusion, Hanser Publishers, 2000.

Course title	**INSTRUMENTATION AND CONTROL ENGINEERING**
Course Code	**25C1MEP-PE1-18**
Scheme and Credits	**L T P C Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain the working principles of measuring instruments.
CO 2	develop mathematical models for control systems.
CO 3	analyze time domain responses of control systems.
CO 4	design control systems using frequency domain techniques.
CO 5	evaluate system stability using Routh-Hurwitz criterion.
CO 6	apply signal flow graphs in control system analysis.

UNIT 1: Measuring Instruments (10 Hrs.)

Principle of operation of galvanometer, PMMC, Moving Iron instruments, Resistance measurements using Wheatstone bridge, Kelvin Double Bridge, Ohm meter, AC bridges: Maxwell bridge, Maxwell Wein bridge, Hey's Bridge, Schering Bridge, Anderson Bridge, Campbell Bridge.

UNIT 2: Instrumentation for Generation and Analysis of Waveforms (8 Hrs.)

Signal generators: Fixed and variable AF oscillators, AF sine and square wave generator, Function generator: Square and pulse generator, Sweep generator, wave analyzer, Harmonic distortion analyzer, Spectrum analyzer, Spectrum analysis.

UNIT 3: Introductory Concepts (8 Hrs.)

Plant, Systems, Servomechanism, regulating systems, Disturbances, Open loop control system, Closed loop control systems, Linear and non-linear systems, Time variant and invariant, Continuous and sampled-data control systems, Block diagrams, some illustrative examples.

UNIT 4: Modelling (8 Hrs.)

Formulation of equation of linear electrical, Mechanical, Thermal, Pneumatic and hydraulic system, Electrical, Mechanical analogies. Transfer function, Block diagram representation, Signal flow graphs and associated algebra, Characteristics equation.

UNIT 5: Time Domain Analysis (8 Hrs.)

Typical test - Input signals, Transient response of the first and second order systems. Time domain specifications, Dominant closed loop poles of higher order systems, Steady state error and coefficients, Pole-zero location and stability, Routh-Hurwitz Criterion.

UNIT 6: Frequency Domain Analysis (10 Hrs.)

Closed loop frequency response, Bode plots, Stability and loop transfer function. Frequency response specifications, Relative stability, Relation between time and frequency response for second order systems. Log. Magnitude versus Phase angle plot, Nyquist criterion for stability.

UNIT 7: Control Component (8 Hrs.)

Error detectors - Potentiometers and synchros, servo motors, A.C. and D.C. techno generators, Magnetic amplifiers.

Suggested References/Books:

1. B.C. Nakra and S.P. Singh, Theory and Applications of Automatic Controls, New Age International Publishers, 2000.
2. A.K. Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Company, 2006.
3. W.D. Cooper, Electronic Instrumentation and Measurement Techniques, Prentice Hall, 2000.
4. H.S. Kalsi, Electronic Instrumentation, Tata McGraw-Hill, 2004.
5. R.C. Dorf and R.H. Bishop, Modern Control Systems, 12th ed., Addison-Wesley, Pearson, New Delhi, 2011.
6. K. Ogata, Modern Control Engineering, 5th ed., Prentice Hall, 2010.

Course title	**ADVANCED INTERNAL COMBUSTION ENGINES**
Course Code	**25C1MEP-PE1-19**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	identify major pollutants, emission standards and Bharat Stage norms.
CO 2	discuss recent engine technologies and hybrid vehicles.
CO 3	apply knowledge of fuel systems to explain how alternative fuels affect engine operation and the modifications required.
CO 4	analyze the benefits and limitations of recent engine technologies.
CO 5	evaluate emission control technologies and standards effectiveness in reducing engine pollutants.
CO 5	design an optimized engine system integrating recent technologies to minimize emissions and maximize efficiency.

UNIT 1: Spark Ignition Engines (12 Hrs.)

Mixture requirements – Fuel injection systems – Monopoint, Multipoint & Direct injection - Stages of combustion – Normal and Abnormal combustion – Knock - Factors affecting knock – Combustion chambers

UNIT 2: Compression Ignition Engines (14 Hrs.)

Diesel Fuel Injection Systems - Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems – Combustion chambers – Fuel Spray behaviour – Spray structure and spray penetration – Air motion - Introduction to Turbocharging.

UNIT 3: Pollutant Formation and Control (16 Hrs.)

Pollutant – Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters, Selective Catalytic Reduction and Particulate Traps – Methods of measurement – Emission norms and Driving cycles.

UNIT 4: Alternative Fuels **(10 Hrs.)**

Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel - Properties, Suitability, Merits and Demerits - Engine Modifications.

UNIT 5: Recent Trends **(8 Hrs.)**

Air assisted Combustion, Homogeneous charge compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems - Hybrid Electric Vehicles – NOx Adsorbers - Onboard Diagnostics.

Suggested References/Books:

1. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications, 2000.
2. G. Ganeshan, Internal Combustion Engines, Tata McGraw-Hill, 2009.
3. R.B. Mathur and R.P. Sharma, Internal Combustion Engines, Dhanpat Rai & Sons, 2007.
4. D. Smith, Auto Fuel Systems, The Goodheart-Willcox Company, Inc., 1987.
5. E. Chowenitz, Automobile Electronics, SAE Publications, 1995.

Course title	**DESIGN OF STEAM TURBINE**
Course Code	**25C1MEP-PE1-20**
Scheme and Credits	**L T P C Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain principles of impulse and reaction turbines.
CO 2	analyze steam flow through turbine blades.
CO 3	identify energy losses in steam turbines.
CO 4	design regenerative feed heating systems.
CO 5	evaluate governing methods for steam turbines.

UNIT 1: Steam Turbine Types (8Hrs.)

Principal of operations of stream turbines, Comparison of steam engines and steam turbines, Simple impulse turbine, Compounding of steam turbines, Pressure compounded impulse turbine, Simple velocity compounded impulse turbine, Pressure –velocity compounded impulse turbine, Difference between impulse and reaction turbine.

UNIT 2: Flow of Steam through Impulse Turbine Blades (6 Hrs.)

Velocity diagram for impulse turbine, multistage impulse turbine with single row wheel, optimum ratio of blade velocity to steam velocity, impulse blade section, advantages and disadvantages of velocity compounded steam turbines.

UNIT 3: Flow of Steam through Impulse Reaction Turbine Blades (6 Hrs.)

Impulse reaction turbine with similar blade section and half degree reaction (Parsons' Turbine), comparison of enthalpy drop in various stages of reaction turbines, height of impulse turbine stage blading, impulse reaction turbine blade section.

UNIT 4: Energy Losses in Steam Turbine (6 Hrs.)

Energy losses in nozzle, moving blade, wind age, partial admission losses, losses due to wetness of steam, mechanical losses.

UNIT 5: State Point Locus, Reheat Factor and Design Procedure (8 Hrs.)
State point losses for multistage steam turbine, reheat factor, internal and other efficiencies, correction of reheat factor for finite number of stages, design procedure for impulse and impulse reaction turbines.

UNIT 6: Regenerative Feed Heating, Reheating and Water Extraction Cycle(6 Hrs.)
Most ideal regenerative feed reheating cycle, advantages and disadvantages of regenerative feed heating over Rankine cycle, prevention from erosion and corrosion, case study of actual regenerative water extraction cycle.

UNIT 7: Back Pressure, Passout and Mixed Pressure Turbine Cycle (6 Hrs.)
Back pressure turbine, passout turbine, process of passout turbine with single extraction, partial extraction, throttle governing, full extraction, nozzle control, working of mixed pressure turbine.

UNIT 8: Governing and Performance of Steam Turbine (6 Hrs.)
Need of governing, comparison of throttle and nozzle control governing, by pass governing of reaction turbine, speeder gear, governing characteristics.

UNIT 9: Construction, Stress Analysis, Operation and Maintenance of Steam Turbine (8 Hrs).
Construction of nozzle and diaphram, design requirements of nozzle, construction of turbine blade, blade material, vibration of blades, rotor construction and it's balancing, stresses in turbine blading disc, aims and objective of maintenance.

Suggested References/Books:

1. R. Yadav, Steam and Gas Turbines, New Age International Publishers, 2010.
2. P. Shylakkhin, Steam Turbines, Tata McGraw-Hill, 2005.
3. W.J. Kearton, Steam Turbine Theory and Practice, Newnes, 1993.

Course title	**CONVECTIVE HEAT TRANSFER**
Course Code	**25C1MEP-PE1-21**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe governing equations for convective heat transfer.
CO 2	solve laminar flow heat transfer problems.
CO 3	analyze natural convection heat transfer mechanisms.
CO 4	apply turbulence models in convective heat transfer.
CO 5	evaluate heat transfer correlations for engineering applications.

UNIT 1: Governing Equations (10 Hrs.)

Continuity, Momentum and Energy Equations and their derivations in different coordinate systems, Boundary layer Approximations to momentum and energy.

UNIT 2: Laminar External Flow and Heat Transfer (14 Hrs.)

(a) Similarity solutions for flat plate (Blasius solution), flows with pressure gradient (Falkner-Skan and Eckert solutions), and flow with transpiration, (b) Integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature (Duhamel's method), flows with pressure gradient (von Karman-Pohlhausen method).

UNIT 3: Laminar Internal Flow and Heat Transfer (12 Hrs.)

(a) Exact solutions to N-S equations for flow through channels and circular pipe, Fully developed forced convection in pipes with different wall boundary conditions, Forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, (b) Integral method for internal flows with different wall boundary conditions.

UNIT 4: Natural Convection Heat Transfer (14 Hrs.)

Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical plate with constant wall temperature and heat flux conditions, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.

UNIT 5: Turbulent Convection (10 Hrs.)

Governing equations for averaged turbulent flow field (RANS), Analogies between heat and Mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies), Turbulence Models (Zero, one and two equation models), Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations.

Suggested References/Books:

1. W.M. Kays, M.E. Crawford, and B. Weigand, Convective Heat and Mass Transfer, 4th ed., McGraw-Hill International, 2005.
2. S. Kakac and Y. Yener, Convective Heat Transfer, 2nd ed., CRC Press, 1995.
3. A. Bejan, Convection Heat Transfer, 3rd ed., John Wiley & Sons, 2004.
4. F.P. Incropera and D.P. Dewitt, Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley & Sons, 2011.
5. H. Schlichting and K. Gersten, Boundary Layer Theory, 8th ed., Springer-Verlag, 2000.

Course title	**COMBUSTION ENGINEERING**
Course Code	**25C1MEP-PE1-22**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain combustion fundamentals and fuel types.
CO 2	apply stoichiometry to combustion processes.
CO 3	analyze reaction kinetics in combustion.
CO 4	design combustion systems for specific applications.
CO 5	assess emission control strategies in combustion.

UNIT 1: Introduction **(10 Hrs.)**
Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion.

UNIT 2: Thermodynamics of Combustion **(8 Hrs.)**
Thermodynamics properties, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, chemical equilibrium.

UNIT 3: Chemistry of Combustion **(8 Hrs.)**
Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

UNIT 4: Physics of Combustion **(8 Hrs.)**
Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

UNIT 5: Premixed Flame **(10 Hrs.)**
One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame.

UNIT 6: Diffusion Flame **(8 Hrs.)**

Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion.

UNIT 7: Combustion and Environment **(8 Hrs.)**

Atmosphere, Chemical Emission from combustion, Quantification of emission, Emission control methods.

Suggested References/Books:

1. D.P. Mishra, Fundamentals of Combustion, Prentice Hall of India, New Delhi, 2003.
2. K.K. Kuo, Principles of Combustion, John Wiley & Sons, 1986.
3. R.A. Strehlow, Fundamentals of Combustion, McGraw-Hill Book Company, 1984.

Course title	**CONDUCTIVE AND RADIATIVE HEAT TRANSFER**
Course Code	**25C1MEP-PE1-23**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe conductive heat transfer mechanisms, including Fourier's law and heat conduction in solids.
CO 2	analyze external forced convection over surfaces by applying boundary layer theory and convective heat transfer correlations.
CO 3	apply internal forced convection principles to fluid flow and heat transfer in tubes and ducts.
CO 4	design radiative heat transfer systems considering emission, absorption, and view factors between surfaces.
CO 5	evaluate blackbody radiation properties and their significance in thermal radiation heat transfer calculations.
CO 6	solve view factor calculations for radiation exchange between surfaces in enclosure problems.

UNIT 1: Fundamentals of Convection (12 Hrs.)

Physical Mechanism of Convection, Classification of Fluid Flows, Velocity Boundary Layer, Thermal Boundary Layer, Laminar and Turbulent Flows, Heat and Momentum Transfer in Turbulent Flow, Derivation of Convection Equations for a Flat Plate, Solutions of Convection Equations for a Flat Plate, Non-dimensionalized Convection Equations and Similarity, Functional Forms of Friction and Convection Coefficients, Analogies between Momentum and Heat Transfer.

UNIT 2: External Forced Convection (8 Hrs.)

Drag and Heat Transfer in External Flow, Parallel Flow over Flat Plates, Flow across Cylinders and Spheres, Flow across Tube Banks.

UNIT 3: Internal Forced Convection **(10 Hrs.)**

Average Velocity and Temperature, The Entrance Region, General Thermal Analysis, Laminar Flow in Tubes, Turbulent Flow in Tubes.

UNIT 4: Natural Convection **(12 Hrs.)**

Physical Mechanism of Natural Convection, Equation of Motion and the Grashof Number, Natural Convection over Surfaces, Natural Convection from Finned Surfaces and PCB, Natural Convection into Enclosures, Combined Natural and Forced Convection.

UNIT 5: Fundamentals of Thermal Radiation **(8 Hrs.)**

Thermal Radiation, Blackbody Radiation, Radiation Intensity, Radiative Properties, Atmospheric and Solar Radiation

UNIT 6: Radiation Heat Transfer **(10 Hrs.)**

The View Factor, View Factor Relations, Radiation Heat Transfer: Black Surfaces, Radiation Heat Transfer: Diffuse, Gray Surfaces, Radiation Shields and the Radiation Effects, Radiation properties of Gases and Vapors.

Suggested References/Books:

1. Y.A. Çengel and A.J. Ghajar, Heat and Mass Transfer: Fundamentals & Applications, 4th ed., McGraw-Hill, 2011.
2. J.P. Holman, Heat Transfer, 10th ed., Tata McGraw-Hill, 2010.

Course title	**SOLAR ENERGY UTILIZATION**
Course Code	**25C1MEP-PE1-24**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	identify solar energy applications and challenges, including economic and environmental factors.
CO 2	analyze solar radiation measurement techniques such as pyranometers and radiometers for accurate data collection.
CO 3	apply heat transfer principles in the design and optimization of solar thermal systems.
CO 4	design solar collectors tailored for specific applications like water heating, space heating, or power generation.
CO 5	evaluate energy storage methods for solar systems, including sensible, latent, and thermochemical storage.
CO 6	assess photovoltaic technologies and their efficiency, materials, and performance for solar energy conversion.

UNIT 1: Introduction **(6 Hrs.)**
Energy demand and supply, energy crisis, conventional and nonconventional energy resources, solar energy applications.

UNIT 2: Solar Radiation **(6 Hrs.)**
Sun, solar radiation, attenuation by atmosphere, solar radiation on earth, measurement, presentation and utilization of data.

UNIT 3: Heat Transfer Concepts **(8 Hrs.)**
Radiation characteristics of surface and bodies, absorbance, reflectance and transmittance, selective surface, sky radiation and wind convection.

UNIT 4: Flat Plate Collectors **(6 Hrs.)**
General description of flat plate collectors, general characteristics, performance, short term and long term performance, design.

UNIT 5: Focusing Collectors **(6 Hrs.)**
General description of focusing solar collectors, concentrators, receivers and orienting systems, general characteristics, performance, materials, design.

UNIT 6: Energy Storage **(6 Hrs.)**
Energy storage in solar process system, different types of storages, characteristics and capacity of storage medium, solar pond.

UNIT 7: Solar Heating and Cooling **(8 Hrs.)**
Passive heating and cooling, nocturnal radiations, green house concept, ponds, active heating and cooling, solar water heaters, absorption cooling, combined solar heating and cooling systems, performance, economics of solar heating and cooling.

UNIT 8: Solar Process Modeling **(6 Hrs.)**
Solar process systems and components, component models, system models.

UNIT 9: Solar Photovoltaics **(8 Hrs.)**
Description and principle of working, performance characteristics, efficiency of solar cells, module design, PV systems, applications.

Suggested References/Books:
1. J.A. Duffie and W.A. Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, 1991.
2. D.Y. Goswami, F. Kreith, and J.F. Kreider, Principles of Solar Energy, Taylor & Francis, 1999.
3. S.P. Sukhatme and J.K. Nayak, Solar Energy, 3rd ed., Tata McGraw-Hill, 2008.
4. H.P. Garg and J. Prakash, Solar Energy, Tata McGraw-Hill, 2000.
5. G.N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications, Narosa Publishing House, 2002.
6. A.B. Meinel, Applied Solar Energy, Addison-Wesley, 1976.

Course title	**DESIGN OF HVAC SYSTEMS**
Course Code	**25C1MEP-PE1-25**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain HVAC system fundamentals and psychrometrics, properties of moist air and processes.
CO 2	calculate cooling and heating loads for buildings using relevant methods and standards.
CO 3	design air distribution systems for HVAC applications, focusing on ductwork, diffusers, and ventilation.
CO 4	select appropriate HVAC equipment such as chillers, air handling units (AHUs), and cooling towers based on system requirements.
CO 5	evaluate HVAC system performance and efficiency through energy analysis and performance metrics.
CO 6	plan HVAC installation and documentation processes, ensuring compliance with codes and best practices.

UNIT 1: Introduction to HVAC **(8 Hrs.)**
Scope, Concepts of air conditioning system, Central air conditioning system, Psychometric chart, Components of AHU and its components

UNIT 2: Refrigerant **(4 Hrs.)**
Types, Evaporating and condensing properties, Refrigerant pipe sizing methods

UNIT 3: Cooling & Heating Load Estimations **(6 Hrs.)**
Basics of heat transfer in building, Understanding of outdoor & indoor conditions, Sources of heat gain, Heat loss calculations

UNIT 4: Design of Air Distribution System **(6 Hrs.)**
Components of air distributing system

UNIT 5: Design of Ventilation System **(4 Hrs.)**
Introduction, Restaurant and kitchen ventilation system design

UNIT 6: Chilled Water System Design **(8 Hrs.)**
Introduction, Classification, Chillar arrangements, Cooling tower arrangements, types of cooling tower & expansion tank connections. Pumps required in chilled water system, Chilled water system pipe designing

UNIT 7: Equipment Selection **(8 Hrs.)**
AHU & FCU classification and selection, Package unit selection DX-Chiller selection, Cooling tower selection mixed air temperature calculation. HRF for open & closed compressor, Expansion tank selection

UNIT 8: Erection of Equipment's **(6 Hrs.)**
Detailing & Installation of Chillers, Detailing & Installation of Air handling units, Detailing & Installation of Package units, Detailing & Installation of Fan coil units. Detailing & Installation of Condensing units

UNIT 9: Estimation of Systems **(6 Hrs.)**
Understanding the tendering requirements, Quantity take off, Preparing inquiry for suppliers & finalizing the suppliers, Final billing & quotations finalization

UNIT 10: Drafting of HVAC Systems **(4 Hrs.)**
Introduction, preparation of floor drawings, Project work Load calculation, Duct designing & Equipment selection

Suggested References/Books:
1. R. McDowall, Fundamentals of HVAC Systems, Elsevier Science, 2007.
2. E. Silberstein, B. Johnson, B. Whitman, and J. Tomczyk, Refrigeration and Air Conditioning Technology, Cengage Learning, 2012.
3. S.K. Wang, Handbook of Air Conditioning and Refrigeration, McGraw-Hill, 2001.

Course title	**DESIGN AND OPTIMIZATION OF THERMAL SYSTEMS**
Course Code	**25C1MEP-PE1-26**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	describe system design concepts and market analysis, including customer needs and competitive assessment.
CO 2	apply numerical methods for thermal system simulation, such as finite difference and finite element techniques.
CO 3	analyze regression techniques for system optimization to identify key parameters and improve performance.
CO 4	formulate optimization problems for thermal systems, defining objectives, constraints, and decision variables.
CO 5	evaluate advanced optimization techniques like genetic algorithms and their applications in thermal systems.
CO 6	design optimized thermal systems tailored for specific applications, balancing efficiency, cost, and performance.

UNIT 1: Introduction **(16 Hrs.)**

Introduction to design and specifically system design. Morphology of design with a flow chart. Market analysis, profit, time value of money, an example of discounted cash flow technique. Concept of workable design, practical examples on workable system and optimal design.

UNIT 2: System Simulation **(14 Hrs.)**

Classification. Successive substitution method - examples. Newton Raphson method - one unknown - examples. Newton Raphson method - multiple unknowns - examples. Gauss Seidel method - examples. Rudiments of finite difference method for partial differential equations, with examples.

UNIT 3: Regression and Curve Fitting (12 Hrs.)

Need for regression in simulation and optimization. Concept of best fit and exact fit. Exact fit- Lagrange interpolation, Newton's divided difference - examples. Least square regression - theory, examples from linear regression with one and more unknowns - examples. Power law forms - examples. Gauss Newton method for nonlinear least squares regression – examples.

UNIT 4: Optimization (18 Hrs.)

Introduction. Formulation of optimization problems – examples. Calculus techniques – Lagrange multiplier method – proof, examples. Search methods – Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden section search – numerical examples. Method of steepest ascent/ steepest descent, conjugate gradient method – examples. Geometric programming – examples. Dynamic programming – examples. Linear programming – two variable problem – graphical solution. New generation optimization techniques – Genetic algorithm and simulated annealing - examples. Introduction to Bayesian framework for optimization examples.

Suggested References/Books:

1. C. Balaji, Essentials of Thermal System Design and Optimization, Aue Books, New Delhi, 2010.
2. Y. Jaluria, Design and Optimization of Thermal Systems, McGraw-Hill, 1998.
3. W.F. Stoecker, Design of Thermal Systems, McGraw-Hill, 1989.
4. J.S. Arora, Introduction to Optimum Design, 3rd ed., McGraw-Hill, 2004.

Course title	**ADVANCED HEAT AND MASS TRANSFER**
Course Code	**25C1MEP-PE1-27**
Scheme and Credits	**L T P C** **Semester – II/III** **4 0 0 4**
Pre-requisite (if any)	**-**
Internal Marks	**50**
External Marks	**100**
Total Marks	**150**

Course Outcomes:

At the end of this course, students will be able to

CO 1	explain advanced heat transfer mechanisms including conduction, convection, and radiation in complex systems.
CO 2	analyze mass transfer processes in engineering systems, focusing on diffusion and convection phenomena.
CO 3	apply numerical methods to simulate heat and mass transfer processes using computational tools.
CO 4	design systems optimized for efficient heat and mass transfer in industrial and environmental applications.
CO 5	evaluate advanced heat transfer correlations for accurate prediction of thermal performance.
CO 6	solve complex heat and mass transfer problems involving combined modes and varying boundary conditions.

UNIT 1: Conduction **(12 Hrs.)**
General conduction equations, boundary & initial conditions, radial fins & fin optimization, multidimensional heat conduction, transient heat conduction.

UNIT 2: Convection **(18 Hrs.)**
Forced convection, velocity and thermal boundary layers, laminar and turbulent flow, boundary layer approximations, convection transfer equations, dimensionless parameters, empirical correlations, free convection, empirical correlations for external free convection flows for various geometries and orientations, heat pipes, Nano fluids and their applications.

UNIT 3: Boiling and Condensation **(16 Hrs.)**

Pool boiling, correlations, forced convection boiling, two phase flow, laminar film condensation on a vertical plate, turbulent film condensation, film condensation in horizontal tubes, drop wise condensation correlations

UNIT 4: Thermal Radiation **(14 Hrs.)**

Thermal radiations and associated laws, radiation exchange between surfaces, view factor, network method, reradiating surfaces. Multimode heat transfer, gaseous emission and absorption.

Suggested References/Books:

1. F.P. Incropera and D.P. Dewitt, Fundamentals of Heat and Mass Transfer, Wiley India, 2002.
2. A. Bejan, Convection Heat Transfer, Wiley India, 2003.
3. K. Sadik and Y. Yaman, Convective Heat Transfer, CRC Press, 1995.
4. W.M. Kays and M.E. Crawford, Convective Heat and Mass Transfer, McGraw-Hill, 2005.
5. M.Q. Brewster, Thermal Radiative Transfer and Properties, John Wiley, 2006.
6. J.P. Holman, Heat Transfer, McGraw-Hill, 2007.