

**B. Tech. (Mechanical Engineering)
Semester III (Second Year)**

Code		Category	Course Title	Hours/Week			Total	Credits	Marks		
Department	University			L	T	P			CIE	SEE	Total
ME 5301C	7-1-3-01R25	MA-BS	Complex Analysis & Partial Differential Equations	3	0	0	3	3	40	60	100
ME 5302C	7-0-3-01R25	CM-HS	Managerial Economics and Financial Accountancy	3	0	0	3	3	40	60	100
ME 5303C	7-5-3-03R25	CE-ES	Mechanics of Solids	3	0	0	3	3	40	60	100
ME 5304L	7-5-3-04R25	ME-PC	Computer Aided Machine Drawing	2	0	3	5	3.5	40	60	100
ME 5305C	7-5-3-05R25	ME-PC	Manufacturing Processes	3	0	0	3	3	40	60	100
ME 5306C	7-5-3-06R25	ME-PC	Thermodynamics	3	0	0	3	3	40	60	100
ME 5307L	7-5-3-R25 P1	CE-ES	Mechanics of Solids Lab	0	0	3	3	1.5	40	60	100
ME 5308S	7-5-3-R25S1	ME-SC	MATLAB Software Lab	1	0	2	3	2	40	60	100
ME 5309M	7-0-3-R25M1	ME-HS	Constitution of India	2	0	0	2	0	100	0	100
ME 5310N		ME-NG	NCC/NSO/ NSS								
TOTAL				20	0	8	28	22	420	480	900

All interested students are advised to **register for Minors degree or Honors degree** at the end of this semester by submitting filled in registration form available from the Head of the Department /Chair person, Board of Studies (UG) of the parent department.



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COMPLEX ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-1-3-01R25	CH, CE & ME

Course Objectives:

1. This course aims at providing the student to acquire the knowledge on the calculus of Functions of complex variables.
2. To understand power series and expansion of analytic function, poles, singular points, Residue Theorem and its applications
3. To familiarize the students with the techniques of Fourier series and evaluating improper integrals
4. The aim is to analyze the solutions of partial differential equations.
5. To discuss the boundary value problems, one-dimensional wave equation, heat equation And Laplace Equation.

UNIT - I

Complex analysis - I: Analytical functions - Cauchy-Reimann equations – Construction of Analytic functions- Complex integration - Cauchy's theorem - Integral formula - Evaluation of integrals.

UNIT - II

Complex analysis - II: Sequences, series, convergence tests, Taylor's and Laurents' series- Singularities - Poles - Residues - Residue theorem – Contour integration- Evaluation of real integrals.

UNIT – III

Fourier series: Fourier series-even and odd functions, periodic functions-half range sine and cosine Series- Gamma and Beta functions

UNIT - IV

Partial differential equations - I : Formation of differential equations - Classification - First order linear partial differential equations – Lagranges' linear equation - Method of multipliers - first order non-linear partial differential equations by Charpit's method.

UNIT- V

Partial differential equations - II: Method of separation of variables - One dimensional wave equation - Heat equation – Laplace's equation.


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Text Books:

1. Grewal B S, Higher Engineering Mathematics, 42th Edition, Khanna Publications, 2007.
2. Venkataraman M K, Engineering Mathematics, National Publishing Company, 1995.
3. Kreyszig E, Advanced Engineering Mathematics, 8th edition, Wiley, 1998.
4. Mathematics-III by T.K.V.Iyenger, B. Krishna Gandhi et al, S. Chand & Company Ltd
5. Mathematical Methods by T.K.V.Iyenger, B. Krishna Gandhi et al, S. Chand & Company Ltd

Course Outcomes: At the end of the course, students will be able to

1. After the completion of course, students will be able to understand the analyticity of complex functions and apply Cauchy's integral formula and Cauchy's integral theorem to evaluate improper integrals along contours.
2. Compute the residue of a function and use the Residue Theory to evaluate a contour integral or an integral over the real line.
3. Find the Fourier Series to represent function as a series of constants sine and cosine Functions of different intervals and evaluate certain improper integrals to make them Simple with introduction of Gamma and Beta functions.
4. Formulation/solve/classify the solutions of Partial differential equations, Identify linear And Nonlinear PDE by different methods.
5. Apply Variables separable methods to solve boundary value problems and find the solution of one-dimensional wave equation, heat equation and Laplace equation.

Mapping of Course Outcomes with Program Outcomes:														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	1	1	1	1	2	1	3	1	3
CO2	3	3	3	3	1	2	2	1	1	2	1	3	1	3
CO3	3	2	2	3	2	1	2	1	1	2	1	3	1	3
CO4	3	2	2	3	2	1	1	1	1	2	1	3	1	3
CO5	3	3	3	2	2	1	1	1	1	2	1	3	1	3

1 – Slightly; 2 - Moderately; 3 – Substantially


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MANAGERIAL ECONOMICS AND FINANCIAL ACCOUNTANCY**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-0-3-01R25	ME

COURSE DESCRIPTION

The objective of the Managerial Economics and Financial Accountancy is to equip students with the tools to make sound business and organisational decisions by analysing economic principles and financial data.

Managerial Economics objectives

1. Decision-making: To enable managers make optimal decisions to maximize a firm's profitability and success by integrating economic theory with business practices.
2. Analysis: To help in the analysis of business situations by providing insights into demand, supply, production functions and costs.
3. Problem-solving: To provide the tools to find optimal solutions for business problems such as those related to pricing, production, capital management, and profit planning.
4. Economic Concepts: To develop understanding of concepts like consumer behaviour, production and cost analysis and market structures.

Financial Accountancy objectives

5. Financial Analysis: To introduce students to financial accounting and analysis techniques, including the use of ratios like liquidity, activity, and profitability.
6. Historical Reporting: To understand how financial accounting records and reports on past performance through final accounts (income statement, balance sheet).
7. Financial Health Assessment: To provide a method for analysing and interpreting financial statements to understand a company's financial position and performance.
8. Informed Decisions: While primarily historical, the objective is to provide the information necessary for management and external stakeholders like investors to make informed decisions, even if it's for future forecasting.

Detailed Syllabus**Unit -I**

Managerial Economics: Definition, Characteristics and Scope – Basic economic tools in Managerial Economics. Managerial Economics and its relation with other subjects – Demand and Supply: Concept and Analysis – Time value of money, Cash flow and Time Diagrams – Choosing among alternative investment proposals: Methods of Economic analysis (Pay Back, ARR, NPV, IRR and B/C ratio)


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Unit -II

Depreciation and methods of calculating depreciation (Straight line, Sum of the years digit method, Declining balance method, Annuity method, Sinking fund method) – National income accounting, Methods of estimation, Various concepts of National Income, Significance of National income Estimation and limitations.

Unit -III

Types of Industrial Organization: Characteristics of Industrial organization, Features and evaluation of Sole Proprietorship, Partnership, Joint Stock Company, State/Public Enterprises and their types – The Business cycles and their relevance to decision making – Inflation: Definition, Process of inflation and measure of controlling inflation – New Economic Policy 1991 (Industrial Policy, Trade Policy, Fiscal Policy). It's Impact on Industry.

Unit -IV

Accounting Principles, procedure, Double entry system, Journal, Ledger, Trial balance, Cashbook – Preparation of Trading account and Profit and Loss account, Balance sheet.

Unit –V

Cost Accounting: Introduction, Classification of costs, Methods of costing, Techniques of costing – Cost sheet and preparation of cost sheet – Break-even Analysis: Meaning, its application and Limitation.

Text Books

1. Gupta, G.S. (2018), Managerial Economics (2e), McGraw Hill Education (India) Pvt. Ltd., Chennai.
2. Dewett. K.K. (2006), Modern Economic Theory, Sultan Chand and Co., New Delhi.
3. Agarwal A.N. (2019), Indian Economy, New Age International Pvt. Ltd., New Delhi.
4. Jain and Narang (2011), Accounting Part-I, Kalyani Publishers, New Delhi.
5. Arora, M.N. (2012), Cost Accounting: Principles and Practice (12e), Vikas Publication, New Delhi.

Reference Books

1. Henry Malcom Steiner (1996), Engineering Economics Principles (2e), McGraw Hill Education.
2. Leland Blank and Anthony Tarquin (2012), Engineering Economy (7e), McGraw Hill, New York.



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Course Outcomes: After the completion of the course the student will be able to;

CO1	Understand the concepts of financial management and smart investment.
CO2	Identify various cost elements of the product and its effect on decision making.
CO3	Understand Economic and regulatory environment of the business and its impact on enterprises.
CO4	Prepare the Accounting records and interpret the data for Managerial Decisions.
CO5	Identify various cost elements of the product and its effect on financial decision making.

Mapping of Course outcomes with program outcomes:

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

1 – Slightly; 2 - Moderately; 3 – Substantially

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MECHANICS OF SOLIDS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-5-3-03R25	ME

Pre-Requisites:

Studying Mechanics of solids requires knowledge of Engineering Mechanics. One should have sufficient knowledge about Moments, Forces, System of forces, Centroids, Moment of Inertia, Stress and strain.

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. To enable students to analyze and determine principal stresses and strains in structural members subjected to complex loading conditions using both analytical methods and graphical methods, and to apply various theories of failure to predict the safety of materials.
2. To teach the concepts of Shear Force and Bending Moment and develop the skill to draw SFD and BMD for different types of beams
3. To provide a rigorous understanding of the Theory of Simple Bending and shear stress distribution, enabling students to calculate flexural and shear stresses in various cross-sections.
4. To equip students with methods to calculate the slope and deflection of beams to ensure serviceability, and to analyze circular shafts under pure torsion and combined loading for power transmission applications.
5. To impart knowledge on the analysis of stresses and strains in thin and thick cylinders subjected to internal and external fluid pressures, applicable in the design of boilers, pipelines, and storage tanks.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

Principle stresses and strains- Introduction-Stresses on an inclined section of a bar under axial loading-Compound Stresses-Normal and tangential stresses on an inclined plane for biaxial stresses-Two perpendicular normal stresses accompanied by a state of simple shear- Principal stresses and strains- Analytical and graphical solutions.

Theories of failures- Introduction-Various theories of failure-Maximum Principal Stress Theory, Maximum Principal Strain Theory, Strain Energy and Shear Strain Energy Theory (Von Mises Theory).

UNIT II:**(L-12+ P-0 =12)**

Shear Force and Bending Moment: Definition of beam- Types of beams- Concept of shear force and bending moment- S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed loads, uniformly varying loads and combination of these loads- Point of contra flexure- Relation between S.F , B.M and rate of loading at a section of a beam.

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UNIT III: (L-12 + P-0 =12)

Flexural Stresses: Theory of simple bending - Assumptions - Derivation of bending equation: $M/I = f/y = E/R$, neutral axis -Determination bending stresses - section modulus of rectangular and circular sections (Solid and Hollow), I and T-angle and Channel sections - Design of simple beam sections.

Shear Stresses: Derivation of formula - Shear stress distribution across various beams sections like rectangular, circular, triangular, I and T-angle sections.

UNIT IV: (L-12 + P-0 =12)

Deflection Of Beams: Definitions of slope, deflection– Relation between slope, deflection and radius of curvature - Differential equation for the elastic line of a beam - Double integration and Macaulay's methods - Cantilever and simply supported beams subjected to point loads - U.D.L uniformly varying load- Moment area method - application to simple cases including overhanging beams.

Torsion Of Circular Shafts: Theory of Pure Torsion in Solid and Hollow circular shafts - Torsional Shear Stresses and angle of twist - transmission of Power -Combined bending and torsion and end thrust-Design of shafts according to theories of failure.

UNIT V: (L-12 + P-0 =12)

Thin Cylinders: Types of stresses in a thin cylinder due to internal pressure- Assumptions- Failures of a thin cylinder- Hoop or Circumferential stress – Longitudinal stress- Maximum shear stress- Change in dimensions and volume of thin cylinders- Riveted boiler shells- thin spherical shells.

Thick Cylinders: Lamé's equation- thick cylindrical shell subjected to both internal and external pressures- Stresses in Compound thick cylindrical shells.

TEXT BOOKS:

1. Strength of Materials (Mechanics of Solids) by J.K. Gupta and S.K. Gupta, Cengage Learning India Private Limited, 2019, ISBN-13: 978-93-5350-100-6.
2. Mechanics of Structures (Vol-I) by Junnarkar S.B and Dr. H.J. Shah, Charotar Publishing House, 2012.
3. Strength of Materials by R.K. Bansal, Laxmi Publishers, 5th Edition, 2012.
4. Strength of Materials by Dr. Sadhu Singh, Khanna Publishers, 10th Edition, 2010.
5. Strength of Materials by S S Rattan, The McGraw-Hill Companies, 2nd Edition, 2011.

REFERENCE BOOKS:

1. Beer, F.P, Johnston, E.R., Mechanics of Materials, McGraw-Hill Education -7th Edition, ISBN: 9780073398235, 2015.
2. Ramamurtham S, Strength of Materials, Dhanpat Rai Publications, ISBN: 978-9384378267, 2014.
3. 3. Mechanics of Materials by Gere and Timoshenko, C B S Publishers & Distributors, 2nd Edition, 2004.



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COURSE OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. Determine principal stresses and identify the appropriate theory of failure for a given material and loading.
2. Construct Shear Force and Bending Moment diagrams for beams under complex loading.
3. Apply bending and shear stress formulas to design beam cross-sections.
4. Calculate beam deflections and design circular shafts for torque transmission.
5. Analyze the stress distribution in thin and thick cylindrical shells.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2									1	3	2
CO2	3	3	2									1	3	2
CO3	3	3	3									1	3	2
CO4	3	3	3									1	3	2
CO5	3	3	2									1	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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COMPUTER AIDED MACHINE DRAWING**Credits: 3.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	2-0-3	7-5-3-04R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is to prepare the students to

1. Develop the ability to create and interpret 2D and 3D engineering drawings using standard drafting practices.
2. Familiarize students with drawing standards, dimensioning systems, GD&T, and symbols used in mechanical engineering.
3. Enable understanding and preparation of drawings of machine elements such as fasteners, couplings, and joints.
4. Train students to prepare assembly drawings and exploded views of mechanical components and systems.
5. Enhance skills in preparing detailed part drawings suitable for manufacturing and inspection.

COURSE CONTENT:**Unit – I****Introduction of 2-D and 3-D modeling:**

Part Navigator, Master model drawings and drafting standards, drawing sheets, Drafting views Custom views, Move, copy, and align views, hiding geometry in drafting views, Updating drawings and drafting views, Centerline symbols, Dimensions, Notes and labels, Balloon, symbols, GD&T symbols, Surface finish, weld, and custom symbols, Section views, Editing section lines, Maintaining associativity, Detail views, View boundaries, Broken views, Break-out section views, View dependent edits, Part Attributes, Parts lists, Sectioning assembly views, exploded views, ordinate dimensions, Hole Tables.

Unit - II

Machine Elements: Drawing views of the following machine elements: Thread profiles, Bolted joint, machine and cap screws, types of nuts, Foundation Bolts.

Unit – III

Shaft Couplings: Muff Coupling, Flanged Coupling,

Riveted Joints: Different types of rivet heads, Different types of lap joints and butt joint.



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Unit – IV

Assembly Drawing: Preparation of assembly drawing of Plumber Block, Foot Step Bearing, Screw jack, Stuffing Box, Pipe Vice, Clapper box, Drill Jig, Cross head, Air cock.

Unit – V

Part Drawing: Preparation of part drawing of IC engine connecting rod, Revolving Centre, Square tool post, Eccentric, Drill jig.

TEXT BOOKS:

1. Narayana K.L, Kannaiah P. and Venkata Reddy K.: Machine Drawing, Third Edition, New Age International, 2006
2. K.C. John: Text Book of Machine Drawing, PHI Learning Private Ltd, 2010.
3. Narayana K.L, Kannaiah P. and Venkata Reddy K.: Production Drawing, Second Edition, New Age International, 2010 reprint.

REFERENCE BOOKS:

1. Bhatt N.D.: Machine Drawing, Charotar Publishers, 2008
2. Dhawan R.K.: Machine Drawing, Second Edition, S. Chand & Company Limited, 1998
3. Engineering Drawing and Design, Author: David A. Madsen, David P. Madsen

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Create and modify 2-D and 3-D CAD drawings using standard drafting views, dimensions, symbols, and annotations.
2. Draw basic machine elements such as threads, bolts, nuts, screws, and foundation bolts using standard conventions
3. Prepare drawings of shaft couplings and riveted joints following standard engineering drawing practices.
4. Develop assembly drawings of mechanical components with proper sectioning and parts listing.
5. Prepare detailed part drawings of machine components with correct dimensions and surface finish details.



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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES: Machine Drawing

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	3	1	2	0	0	0	2	0	2	0	2	1
CO2	3	2	2	1	2	0	0	0	1	0	2	2	0	0
CO3	2	3	2	3	2	0	0	0	0	0	0	0	3	2
CO4	3	1	0	2	0	0	0	0	0	3	2	0	2	2
CO5	3	1	0	0	3	0	0	0	1	3	0	0	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially



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MANUFACTURING PROCESS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-5-3-05R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The vital learning objectives of this course are

1. To provide fundamental conceptual knowledge about metal working processes in general and exploring the principles of mechanization and automation including flexible manufacturing system to transform the raw material into a usable and valuable product.
2. To develop the thorough understanding of metal casting principles including pattern making, core making, preparation of sand mould and solidification process in getting the final shape of the cast product.
3. To give insight into elastic and plastic deformations of metals and to explain typical forming operations such as rolling and forging methods along with their force analysis.
4. To disseminate knowledge (to the student) on how to produce metal parts to the required shape without removing any material by extrusion and drawing techniques of plastic deformation processes.
5. To explain simply and briefly what the sheet metal working is all about with the aid of press tools and to throw light on fabrication of metal products by welding, soldering and brazing.

COURSE CONTENT:**UNIT I:****(L-12)**

Difference between manufacturing and production – Classification of Manufacturing Processes – Production Systems – Types of layouts – Functions in manufacturing – Mechanization and Automation – Types (levels) of automation – Flexible Manufacturing System Layout.

UNIT II:**(L-12)**

Pattern making – Pattern allowances – Types of Patterns – Sand moulding – Sieve Analysis – Permeability number – Types of Cores – Core making – Core boxes – Chaplets – Flask Moulding – Machine Moulding – Risers and Directional Solidification – Shell Moulding – Investment Casting.

UNIT III:**(L-12)**

Deformation of metals – elastic and plastic deformation – force – extension curve – Cold working and hot working of metals. Rolling – Flat rolling – Force and Power in rolling. Forging – Open die forging – Forging force – Impression die forging – Closed – die forging – Forging machines.

UNIT IV:**(L-12)**

Extrusion and Drawing – Introduction – Different types of extrusion processes – Equipment – Defects in extrusion – Drawing processes – Drawing practice – Drawing equipment

UNIT V:**(L-12)**

Sheet metal forming processes – Shearing and cutting – Blanking and piercing – press tool set – Bending – Deep drawing


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Fabrication processes – Classification – Joining processes – Fusion welding processes – Solid state welding processes – Soldering and Brazing

TEXT BOOKS:

1. **SeropeKalpakjian**: Manufacturing Engineering and Technology, 5th Edition, Pearson Prentice Hall, 2005.
2. **P.N. Rao**: Manufacturing Technology, 2nd Edition, Tata McGraw – Hill, 2007
3. **P.C. Sharma**: Production Technology: Manufacturing Processes, 7th Edition, S. Chand and Company, Ltd, 2007.

REFERENCE BOOKS:

1. **J.P. Kaushish**: Manufacturing Processes, 2nd Edition
2. **R.S. Khurmi and J.K. Gupta**: Workshop Technology: Manufacturing Processes, 7th Edition, S. Chand and Company, Ltd, 2007.
3. **HajraChoudury S.K.**: Element of Workshop Technology, Volume – 1, Indian Book Distribution Co, Kolkata

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Distinguish between manufacturing and production and differentiate between mechanization and automation entities, devising a suitable plant layout for a typical manufacturing industry and assessing on value addition by manufacturing automation.
2. Design and make a wooden pattern for its use in making a sand mould cavity to cast a product of required size and shape.
3. Represent the mechanical behaviour (properties) of metals under elastic and plastic deformation processes and understanding bulk deformation processes such as rolling and forging methods including force analyses of the same.
4. Distinguish between forward extrusion and backward extrusion and to explain the different methods of drawing (tube, bar, and rod). Also identifying defects in extruded parts and acquiring familiarity with equipment required for extrusion and drawing processes.
5. Shape the metal parts by blanking, piercing, bending and deep drawing methods collectively called as sheet metal working. And acquainted with joining of metals by fusion welding techniques and identifying brazed and soldered joints.

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	2	1	3	1	3	1	1	1	1	2	1	2	3	2
CO2	1	1	2	1	3	1	1	1	1	2	1	1	3	2
CO3	1	2	1	1	3	1	1	1	1	2	1	2	3	2
CO4	1	1	3	1	3	1	1	1	1	2	1	1	3	2
CO5	1	1	2	1	3	1	1	1	1	3	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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THERMODYNAMICS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-5-3-06R25	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Understand the fundamental concepts of thermodynamics, including systems, properties, processes, and equilibrium conditions.
2. Apply the First Law of Thermodynamics to analyze energy interactions in closed and open systems under steady and unsteady conditions.
3. Comprehend the limitations of the First Law and apply the Second Law of Thermodynamics to evaluate the performance of heat engines, refrigerators, and heat pumps.
4. Analyze the concepts of entropy, exergy, and irreversibility for assessing the efficiency and effectiveness of thermodynamic systems.
5. Study and compare the performance of various thermodynamic and air-standard cycles such as Otto, Diesel, Dual, Brayton, and Stirling cycles used in engineering applications.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

Introduction: System, boundary, Surrounding, Universe, control volume, Types of Systems, Macroscopic and Microscopic viewpoints, Thermodynamic Equilibrium, State, Property, Process – Reversible, Quasi static & Irreversible Processes, cycle, Causes of Irreversibility. Point and Path function. Zeroth Law of Thermodynamics – Concept of Temperature – Principles of Thermometry – Scales of Temperature.

UNIT II:**(L-12+ P-0 =12)**

First law of thermodynamics: First Law for Cyclic & Non-cyclic processes; Concept of total energy E; Demonstration that E is a property; Various modes of energy, Internal energy and Enthalpy; First Law of Thermodynamics and Flow Processes - Derivation of general energy equation for a control volume; Steady state steady flow processes including throttling; Unsteady processes; examples of steady unsteady First law applications for system & control volume



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UNIT III:**(L-12 + P-0 =12)**

Second law of thermodynamics: Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence, Corollaries, PMM of Second kind, Carnot cycle and its specialties, Carnot's theorem, Thermodynamic scale of Temperature. Clausius Inequality, Entropy, Principle of Entropy Increase, Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics.

UNIT IV:**(L-12 + P-0 =12)**

Exergy: Available energy, Useful work, Dead state, Availability, Irreversibility, Compressibility charts- Properties of two- phase systems - Const. temperature and Const. pressure heating of water.

UNIT V:**(L-12 + P-0 =12)**

Thermodynamic and Air standard cycles -; Basic Brayton cycle; Introduction to basic concepts of Gas Turbines; Sterling Engine, Otto, Diesel and Dual cycles; Air Standard Efficiency and comparison with Carnot Cycle Efficiency.

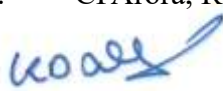
Introduction To fuels & combustion: - Fuels, Solid, Liquid, Gaseous Fuels- Properties of Fuels. Conventional fuels-calorific value of fuels (solid-liquid and gaseous).

TEXT BOOKS:

1. R.K. Rajput, 2007, 3rd Edition, Engineering Thermodynamics, Laxmi Publications (P) LTD.
2. Nag, P.K, 1995, *Engineering Thermodynamics*, Tata McGraw-Hill Publishing Co. Ltd.
3. Domakundwar and Kothandaraman, *A Course in Thermal Engineering* Moran, M. J. and Shapiro, H. N., 1999, *Fundamentals of Engineering Thermodynamics*, John Wiley and Sons.
4. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., 2003, 6th Edition, *Fundamentals of Thermodynamics*, John Wiley and Sons.

REFERENCE BOOKS:

1. Claus Borgnakke Richard E. Sonntag, Fundamentals of Thermodynamics, 7/e, Wiley, 2009.
2. J.B. Jones, and R.E. Dugan, Engineering Thermodynamics, 1/e, Prentice Hall, 1995.
3. Y.A.Cengel & M.A. Boles, Thermodynamics– An Engineering Approach, 7/e, McGraw Hill, 2010.
4. P. Chattopadhyay, Engineering Thermodynamics, 1/e, Oxford University Press, 2011.
5. C.P. Arora, Refrigeration and Air-conditioning, 4/e, McGraw Hill, 2021.


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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. **Explain** the basic concepts of thermodynamics and identify different types of systems, processes, and properties.
2. **Apply** the First Law of Thermodynamics to analyze energy transfer and work interactions in both closed and open systems.
3. **Interpret and evaluate** the Second Law of Thermodynamics to determine the performance of heat engines, refrigerators, and heat pumps.
4. **Analyze** entropy, availability (exergy), and irreversibility to assess the efficiency and losses in thermodynamic processes.
5. **Examine and compare** the performance of various thermodynamic and air-standard cycles such as Otto, Diesel, Dual, Brayton, and Stirling cycles.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	2	1	1	1	1	2	1
CO2	3	3	2	2	1	1	1	1	2	1	1	1	3	2
CO3	3	3	3	2	2	1	1	2	1	1	1	1	3	2
CO4	3	3	2	3	2	1	2	1	1	1	1	2	3	3
CO5	3	2	3	2	2	1	1	1	1	1	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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MECHANICS OF SOLIDS LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	0-0-3	7-5-3-R25P1	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To provide practical knowledge of the behavior of various materials under different types of loading conditions such as tension, compression, shear, torsion, and bending.
2. To determine essential mechanical properties of materials, including Young's Modulus (E), Modulus of Rigidity (G), Yield Strength, Ultimate Strength.
3. To bridge the gap between theory and practice by experimentally verifying the laws of mechanics, such as beam deflection formulas and spring constants.
4. To study the performance of structural components like beams, springs, and joists under load to understand failure mechanisms.
5. To assess the dynamic behavior of materials by performing impact tests and determining the energy absorption capacity of metals under sudden shock loading.

LIST OF EXPERIMENTS:

1. Tension on Mild Steel bar.
2. Tension on HYSD Steel bar.
3. Compression Test on Wood
4. Shear Test on Wood
5. Torsion test on Steel.
6. Test on Closed coil Helical Spring
7. Bending Test on Rolled Steel Joist
8. Bending Test on Carriage Spring
9. Charpy Impact Test
10. Deflection Test on a beam under Uniform Bending
11. Deflection Test on Simply Supported Beam
12. Deflection Test on Fixed Beam



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COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Perform tensile tests on Mild Steel and HYSD bars to plot Stress-Strain curves and determine properties like Yield Stress, Ultimate Stress, Percentage Elongation, and Young's Modulus and perform compression tests to evaluate the crushing strength of materials like wood.
2. Calculate the Modulus of Rigidity (G) of steel sections by subjecting them to torsional loading.
3. Analyze Stiffness of Springs Test close-coiled helical springs and carriage springs to determine their spring constant and modulus of rigidity.
4. Evaluate the flexural strength of structural members. Measure and verify the slope and deflection of beams under various boundary conditions and compare them with theoretical values.
5. Determine the toughness and energy absorption capacity of metal specimens under sudden loading.

Mapping of Course Outcomes with Program Outcomes:

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

1 - Slightly; 2 - Moderately; 3 – Substantially


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MATLAB SOFTWARE LAB**Credits: 2****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
III	1-0-2	7-5-3-R25S1	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The vital learning objectives of this course are

1. To introduce Matlab environment, its desktop, basic commands and syntax, arrays, matrices and their manipulations and operations.
2. To inculcate programming abilities in writing simple script and function files, use of control loops in writing programs and to describe how to use Matlab to create and format different types of two – dimensional, three – dimensional and multiple plots.
3. To impart knowledge about matrix methods of solving systems of linear equations and preliminaries to symbolic mathematics
4. To give insight into the applicability of symbolic algebra for solving linear algebraic equations and to perform differentiation and integration of simple mathematical functions by symbolic expressions.
5. To acquaint with numerical differentiation and numerical integration of simple functions and to find a suitable function through the process of curve fitting and interpolation of functions in order to model data points.

Course Content**UNIT – I**

Introduction: What is MATLAB? – MATLAB System – Starting MATLAB on Windows Platforms – MATLAB Environment – Basic commands and Syntax – Arrays and Matrices – Arithmetic and Array operations – Matrix operations and manipulations – Practice Exercises.

UNIT – II

Scripts and Functions: Script and Function files (M – files) – Control loops – Sample/simple Programmes – Basic Plotting – 2D and 3D plotting – Multiple plots – Additional plotting features – Practice Exercises.

UNIT – III

Matrix Algebra and Solutions to Systems of Linear Equations: Solving Linear algebraic equations by matrix methods – Polynomials – Symbolic mathematics – Preliminaries – Practice Exercises.

UNIT – IV

Solving Linear algebraic equations by Symbolic mathematics – Differentiation and Integration by Symbolic mathematics – Practice Exercises.



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UNIT – V

Numerical Techniques: Numerical differentiation and Numerical integration – Fitting of data – Curve fitting – Interpolation of functions – Practice Exercises.

TEXTBOOKS:

1. Tobin A. Driscoll: Learning MATLAB, Siam, Cambridge University Press, India, 2005.
1. Hanselman and Littlefield: Mastering MATLAB 7, 1st Edition, PHI, 1997.
2. Rudra Pratap: Getting Started with MATLAB 7, Oxford University Press, 2006.
3. Stevan C. Chapra: Applied Numerical Methods with MATLAB for Engineers and Scientists, 3rd Edition, McGrawHill Companies, Inc, NY, 2012.

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Explain swiftly about Matlab features/environment, basic commands, array and matrix operations and manipulations.
2. Distinguish between a script file and a function file and writing simple programs using control loops, and represent data by 2D/3D and multiple plots for pictorial views.
3. Solve system of linear algebraic equations by matrix methods and formulating symbolic mathematical expressions.
4. Utilize symbolic mathematics for solving linear algebraic equations and performing differentiation and integration of simple mathematical functions.
5. Grasp Matlab commands for curve fitting data, performing interpolation of functions and to execute numerical differentiation and numerical integration of simple mathematical functions including trigonometric functions.

Mapping of Course Outcomes with Program Outcomes:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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CONSTITUTION OF INDIA**Credits: 0****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
III	2-0-0	7-0-3-R25M1	ME

Course Educational Objectives (CEOs):

Students will learn:

1. To Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Unit-I

History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working) Philosophy of the Indian Constitution: Preamble Salient Features

Unit-II

Contours of Constitutional Rights & Duties:

- Fundamental Rights
- Right to Equality
- Right to Freedom
- Right against Exploitation
- Right to Freedom of Religion
- Cultural and Educational Rights
- Right to Constitutional Remedies
- Directive Principles of State Policy
- Fundamental Duties.

Unit-III

Organs of Governance:

- Parliament
- Composition
- Qualifications and Disqualifications
- Powers and Functions
- Executive
- President
- Governor


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- Council of Ministers
- Judiciary, Appointment and Transfer of Judges, Qualifications
- Powers and Functions

Unit-IV

Local Administration:

- District's Administration head: Role and Importance,
- Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.
- Pachayati raj: Introduction, PRI: Zila Pachayat.
- Elected officials and their roles, CEO Zila Pachayat: Position and role.
- Block level: Organizational Hierarchy (Different departments),
- Village level: Role of Elected and Appointed officials,
- Importance of grass root democracy

Unit-V

Election Commission:

- Election Commission: Role and Functioning.
- Chief Election Commissioner and Election Commissioners.
- State Election Commission: Role and Functioning.
- Institute and Bodies for the welfare of SC/ST/OBC and women.

TEXT BOOKS/REFERENCES:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes (COs):

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.


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CO-PO Mapping

PO&PSO/ CO	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)
CO1	2	2	-	-	2	1	2	-	-	2	1	1
CO2	2	1	1	-	1	1	-	-	-	1	1	1
CO3	2	2	-	-	2	1	2	-	-	2	1	1
CO4	-	-	-	-	2	1	2		-	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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B. Tech. (Mechanical Engineering)
Semester IV (Second Year)

Code		Category	Course Title	Hours/Week			Total	Credits	Marks		
Department	University			L	T	P			CIE	SEE	Total
ME 5401C	7-1-4-01R25	MA-BS	Numerical Methods, Probability and Statistics	3	0	0	3	3	40	60	100
ME 5402C	7-5-4-02R25	CE-PC	Fluid Mechanics and Hydraulic Machinery	3	0	0	3	3	40	60	100
ME 5403C	7-5-4-03R25	ME-PC	Kinematics of Machinery	3	0	0	3	3	40	60	100
ME 5404C	7-5-4-04R25	ME-PC	Machine Tools and Metal Cutting	3	0	0	3	3	40	60	100
ME 5405C	7-5-4-05R25	ME-PC	Thermal Engineering	3	0	0	3	3	40	60	100
ME 5406M	7-1-5-09R25	ME-HS	Professional Ethics in Engineering	2	0	0	2	0	100	0	100
ME 5407L	7-5-4-R25 P1	CE-PC	Fluid Mechanics and Hydraulic Machinery Lab	0	0	3	3	1.5	40	60	100
ME 5408L	7-5-4-R25P2	ME-PC	Manufacturing Processes Lab	0	0	3	3	1.5	40	60	100
ME 5409L	7-5-4-R25 P3	ME-PC	Fuels and Lubricants Laboratory	0	0	3	3	1.5	40	60	100
ME 5410S	7-5-4-R25S1	ME-SC	Finite Element Analysis Lab	1	0	2	3	2	40	60	100
ME 5411M	7-0-4-R25M1	CE-ES	Environmental Science	2	0	0	2	0	100	0	100
TOTAL				20	0	11	31	21.5	560	540	1100

All students shall mandatorily register for NCC/NSO/NSS and complete 60 hours of activities beginning from the 1st semester but to be completed before 4th semester in one of these three options to earn **Non-graded (NG) Credits** as core requirement. Grade shall be awarded as Satisfactory or Unsatisfactory by the concerned HoD on the basis of participation, attendance, performance and Behaviour. If a student gets an unsatisfactory Grade, he/she shall repeat the above activity in the subsequent years, in order to complete the degree requirements.

All interested students shall **register for Minors degree or Honors degree** just before or at the time of commencement of this semester by submitting filled in registration form available from the Head of the Department /Chair person, Board of Studies (UG) of the parent department.

Students shall undergo **Community Service Project (CSP)** for a duration of **six to eight (6-8) weeks** during the summer vacation by completing **45 – 60** hours of work with at least **75%** attendance, to be evaluated and reflected in 5th semester.

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NUMERICAL METHODS, PROBABILITY AND STATISTICS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-1-4-01R25	ME

Course Objectives:

1. This course aims at providing the student with the knowledge on Various numerical methods for Solving transcendental equations.
2. To acquaint the students with different types of numerical methods to interpolate the polynomials, numerical derivatives and integrals.
3. To provide suitable and effective methods called Numerical Methods, for differential equations.
4. To provide knowledge of discrete and continuous distributions and problems on Binomial, Poisson, Normal Distributions. Interpret the association of characteristics and through correlation and regression tools.
5. To acquaint the students with different types of large and small sample tests

Unit I : Error analysis, Curve fitting by the method of least squares, Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves, Solutions of Algebraic & Transcendental Equations: Determination of roots of non - linear equations by iterative methods - Falsi position method - bisection method - Newton Raphson method .

Unit-II : Numerical Interpolation, Integration & Differentiation - Newton's forward & backward interpolation formula - Lagrange's interpolation formula. Numerical differentiation with forward and backward differences, Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule.

UNIT - III: Solution Of Ordinary Differential Equations - Taylor series method - Euler's method - Euler's modified method - Runge Kutta second & fourth order methods - Milne's predictor and corrector methods for first order equations.

UNIT - IV: Random variables, Discrete and Continuous distributions, expectation, variance. Distributions: Binomial, Poisson, Normal and Exponential Properties and applications. Correlation – Rank Correlation - Regression analysis.

UNIT - V: Testing of Hypothesis –Large & Small samples-Null and alternate hypothesis, level of significance and critical region-Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means - F-test for comparison of variances, Chi-square test for goodness of fit.



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TEXT BOOK: 1. Higher Engineering Mathematics – B.S. Grewal.

1. Numerical methods by E. Balagurusamy, Tata McGraw-Hill Publishing Co.
2. Numerical Methods for Scientific and Engineering Computation 3rd edition by Jain, New Age International.
3. S P Gupta, Statistical Methods, 38th Edition, Sultan Chand & Sons Educational Publishers, 2009.
4. T. K. V Iyengar et al, Probability and Statistics 2nd Edition, S. Chand & Company Ltd, 2010.
5. S. C. Gupta and V K Kapur, Fundamentals of Applied Statistics, 3rd Edition, Sultan Chand & Sons Educational Publishers.

Course Outcomes: At the end of the course, students will be able to

1. To apply numerical methods to solve the Solution of Linear and Non-Linear Algebraic Equations and curve fitting problems iterative methods.
2. Derive interpolating polynomials using interpolation formulae Test and evaluate the accuracy of Differentiation and integrals numerically.
3. Using numerical methods, we find solution of Ordinary differential equations.
4. Evaluate discrete and continuous probability distributions and able to solve problems on Binomial, Poisson, Normal Distributions. Interpret the association of characteristics and through correlation and regression tools.
5. Design the components of a classical hypothesis test. Infer the statistical inferential methods based on small and large sampling tests.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	2	1	1	1	1	2	1	3	1	3
CO2	3	3	3	3	2	2	2	1	1	2	1	3	1	3
CO3	3	2	2	3	2	1	2	1	1	2	1	3	1	3
CO4	3	2	2	3	1	1	1	1	1	2	1	3	1	3
CO5	3	3	3	3	2	1	1	1	1	2	1	3	1	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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FLUID MECHANICS AND HYDRAULIC MACHINERY**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-5-4-02R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To learn about the application of fluid flow concepts and fundamental equations.
2. To apply the knowledge of flow through pipes and laminar flow in circular pipes.
3. To understand the importance of dimensional analysis and Boundary layer concepts.
4. To design the different types of turbines and analyze their performance.
5. To apply the knowledge of theory of rotodynamic machines and pumps.

COURSE CONTENT:**UNIT I: (L-12)**

Definition of fluid, Units and dimensions- properties of fluids, mass density, specific volume, specific gravity, viscosity, Newton's law of viscosity, compressibility, surface tension and capillarity – Fluid flow characteristics- Velocity, Acceleration, Types of flows – Stream lines, Path lines, Streak lines – Continuity Equation – Energy Equation - Momentum equation - Euler's equation of motion along a stream line- Bernoulli's equation and its applications.

UNIT II: (L-12)

Flow through pipes – Laws of fluid Friction, Darcy-Weisbach equation and other formulae for Head loss due to friction in pipes, Minor losses in pipes, Pipes in Series and Pipes in Parallel, Moody's diagram - Laminar flow through circular pipes, Hagen-Poiseuille Equation.

UNIT III: (L-12)

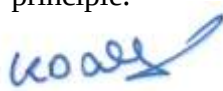
Boundary layer theory, thickness, measurement– Drag force on a flat plate due to boundary layer - Need for dimensional analysis – methods of dimension analysis – Similitude – type of similitude Dimensionless parameters – application of dimensionless parameters – Model analysis.

UNIT IV: (L-12)

Classification of water turbines, heads and efficiencies, velocity triangles – Axial, radial and mixed flow turbines – Pelton wheel, Francis turbine, Kaplan turbine, working principles – Draft tube – Specific speed, Unit quantities, Performance curves

UNIT V: (L-12)

Theory of Rotodynamic machines - various efficiencies – velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, performance curves – Cavitations in pumps- Reciprocating pump – working principle.



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TEXT BOOKS:

1. Hydraulics and Fluid Mechanics by P.N. Modi and S.M. Seth.
2. Fluid Mechanics and Hydraulic Machines by R.K.Rajput.
3. Fluid Mechanics and Hydraulic Machines by R.K.Bansal.

REFERENCE BOOKS:

1.	Fluid Mechanics by V.L. Streeter and E.Benzamine, Wylie
2.	Fluid Mechanics and Turbo machines by Madan Mohan Das.– PHI Learning Pvt.Ltd., New Delhi

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Understand and analyze simple flow situations and solve fluid flow problems.
2. Classify flows and evaluate the flow through pipes and laminar flows.
3. Apply the knowledge of boundary layer theory and dimensional analysis.
4. Design and analyze the characteristics of turbines.
5. Design and evaluate the performance of centrifugal and reciprocating pumps.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO1	PSO2
CO1	1	2	3	1	1	1	1	1	1	1	1	1	1	2
CO2	3	3	3	1	1	1	1	1	1	1	1	1	3	3
CO3	3	3	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	3	1	1	1	2	3	1	1	1	1	1	3	3
CO5	3	3	1	1	1	2	1	1	1	1	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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KINEMATICS OF MACHINERY**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-5-4-03R25	ME

Pre-Requisites: Engineering Mechanics**COURSE OBJECTIVES:** The main learning objective of this course is

1. To enable students to understand the fundamental concepts of mechanisms, types of links, kinematic pairs, degrees of freedom, and inversions, along with their practical applications.
2. To familiarize students with straight-line motion and steering mechanisms, and to analyze their role in achieving precise motion transmission in mechanical systems.
3. To develop the ability to analyze the velocity and acceleration of mechanisms using graphical and analytical methods, and apply these techniques to real-world engineering systems.
4. To impart knowledge of gear profiles, law of gearing, interference, and gear trains, enabling students to calculate velocity ratios and train values for various gear systems.
5. To provide understanding of cam mechanisms, follower motions, and the design of cam profiles for specified operating conditions.

COURSE CONTENT:**UNIT I: (L-10)****BASICS OF MECHANISMS:**

Elements or Links – Classification – Rigid Link, flexible and fluid link –Types of kinematic pairs: sliding, turning, rolling, screw and spherical pairs – lower and higherpairs– closed and open pairs– constrained motion : completely, partially or successfully constrained and incompletely constrained – Degree of freedom, Mobility – Kutzbach criterion, Gruebler's criterion – Grashof's Law – Kinematic inversions of four- bar chain and slider crank chains – Quick return mechanisms – Limit positions– Transmission Angle – Mechanical advantage.

UNIT II: (L-10)**STRAIGHT LINE MOTION MECHANISMS:**

Exact and approximate, copied and generated types –Peaucellier - Hart - Scott Russel – Grasshopper – Watt- Tchebicheff - Robert Mechanisms and Pantograph.

STEERING MECHANISMS:

Conditions for correct steering – Davis Steering gear, Ackerman's steering gear.

UNIT II: (L-10)**VELOCITY AND ACCELERATION ANALYSIS:**

Velocity analysis of various mechanisms using Relative velocity method, Velocity Images, Rubbing Velocity – Instantaneous centers of rotation – Kennedy's theorem and its applications to planar mechanism for velocity analysis – Acceleration of simple mechanisms. Coriolis component of acceleration.

UNIT IV: (L-10)

GEARS: Toothed gears – types – law of gearing, Forms of tooth- cycloidal and involute profiles. Velocity of sliding – phenomena of interference– Methods to avoid interference. Condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact.

GEAR TRAINS: Introduction –Types of gears trains: Simple, Compound, Reverted and Epicyclic gear trains. Train value and Velocity ratios of gear trains.

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UNIT V: (L-10)**CAMS:**

Classification of cams and followers- Terminology and definitions- Displacement diagrams- Uniform velocity, parabolic, simple harmonic and cycloidal motions – Cam profiles for specified motions – disk cam with radial Knife edge follower, roller follower.

TEXT BOOKS:

1. Theory of Machines : S.S.Rathan , 5th Edition, McGraw-Hill Education (India) Private Limited.
2. Theory of Machines : R.S.Khurmi. 14th Edition, S. Chand Publishing.
3. Theory of Machines & Mechanisms : PL. Ballaney, 25th Edition, Khanna Publishers.
4. Mechanisms and Machine theory : J.S.Rao and R.V.Dukkipati., 2nd Edition, New Age International Publishers.

REFERENCE BOOKS:

1. The Theory of Machines : Shigley J.E/Oxford University Press
2. Mechanisms and Dynamics of Machinery : Hamilton Mabie H. and F. W. Ocvirk /Oxford University Press.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand and classify mechanisms, apply mobility criteria, and analyze kinematic inversions.
2. compare different straight-line motion mechanisms and evaluate steering gear mechanisms for correct steering conditions.
3. perform velocity and acceleration analysis of planar mechanisms using relative velocity, instantaneous centers, and Coriolis component concepts.
4. apply the law of gearing, analyze interference, and determine velocity ratios in simple, compound, reverted, and epicyclic gear trains.
5. construct cam profiles for various follower motions and analyze displacement, velocity, and acceleration characteristics of cam-follower systems.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	1	1	1	1	1	1	2	3	2
CO2	3	3	2	1	1	1	1	1	2	2	1	2	3	2
CO3	3	3	1	2	2	1	1	1	1	2	1	2	3	2
CO4	3	3	3	1	2	1	1	1	1	1	2	2	3	2
CO5	3	3	3	1	2	1	1	1	2	2	1	2	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially



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MACHINE TOOLS AND METAL CUTTING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-5-4-04R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The vital learning objectives of this course are:

- To describe tool angles of a single point cutting tool by tool nomenclature/signature and to explain the mechanism of chip formation, construction of composite force circle diagram, and estimation of tool – life in machining of metals.
- To give insight into constructional details, physical principles, tools required, operations done and estimation of machining time in processing of metal on lathe, shaper, and slotter employing single point cutting tools for machining.
- To explain about the specific/selective types of drilling and milling machines, their constructional details, and operations done on them.
- To acquaint with indexing methods in order to cut spur and helical gears on milling machines besides focusing on gear generating and finishing techniques.
- To develop the thorough understanding of broaching machines and grinding wheel manufacture, its dressing, truing and to explore different types of grinding machines in use today.

COURSE CONTENT:**UNIT I:****(L-12)**

Cutting tools: Classification – Nomenclature/Signature of single point cutting tool – Differences between orthogonal cutting and oblique cutting – Mechanism of metal cutting – Types of Chips – Forces on a single point cutting tool – Merchant's circle force diagram – Tool – life and Tool – life equation.

UNIT II:**(L-12)**

Lathe and Shaper: Engine lathe – constructional details – work and tool holding devices – operations done on lathe. Shaper and Slotter – Constructional details – Quick return mechanisms – Estimation of machining time in lathe and shaper.

UNIT III:**(L-12)**

Drilling and Milling Machines: Sensitive, Upright and Radial drilling machines – Constructional details – Operations done on them. Milling methods – Up – cut and Down – cut milling methods Classification of milling machines – Horizontal, Vertical, and Universal milling machines – Operations performed on them. Estimation of machining time in drilling and milling.

UNIT IV:**(L-12)**

Gear cutting by Milling and Finishing Operations: Universal Indexing head and types of indexing methods – Simple, Compound, Differential and Angular Indexing. Spur and Helical gear cutting – Gear generating methods – Gear shaping and Gear Hobbing. Finishing of gear by gear shaving and gear grinding.


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UNIT V:**(L-12)**

Broaching and Grinding Machines: Pull broach and Push Broach – Horizontal and vertical broaching machines – Grinding – Grinding wheels – Manufacturing – cylindrical and centreless grinding – wheel dressing and truing. Different types of grinding machines.

TEXT BOOKS:

1. **SeropeKalpakjian:** Manufacturing Engineering and Technology, 5th Edition, Pearson Prentice Hall, 2005.
2. **HazraChoudary and Bose S.K.:** Workshop Technology Volume II, 10th Edition, Media Promoters and Publishers, Pvt. Ltd., 2000.
3. **B.S. Raghuvamshi:** Workshop Technology Volume II (Machine Tools) , Dhanpat Rai and Co, Pvt. Ltd, 2009.
4. **Haslehurst M:** Manufacturing technology, 3rd Edition, Viva Books Pvt. Ltd, 1998
5. **P.C. Sharma:** Production Engineering, 10th Edition, S. Chand and Company, Ltd, 2008.
6. **Gupta S.C. and Jain R.K.:** Production Technology, 9th Edition, Khanna Publishers, 2002.

REFERENCE BOOKS:

1. HMT: Production Technology, McGraw – Hill Education (India), Pvt., Ltd., 28th Reprint, 2008.

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Distinguish between orthogonal cutting and oblique cutting in addition to possessing conceptual knowledge in metal cutting principles, like, tool signature, mechanism of chip formation, construction of Merchant's circle diagram, utility of tool – life equation.
2. Use correct work holding and tool holding devices on engine lathe to perform various operations on it. And acquainted with mechanisms involved, principles of operation (of lathe, shaper and slotter) and estimation of cutting time in lathe and shaper.
3. Explain working principles, constructional details and primary motions of drilling and milling machine tools and method of calculations of machining times in them.
4. Describe different indexing methods and carrying out gear cutting on milling machines and producing gears by gear generating methods besides finishing of gears by gear shaving and gear grinding techniques.
5. Grasp operational principles of broaching and grinding machines with firm foundation on manufacture of grinding wheel and its process capabilities.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	1	3	1	1	1	1	1	1	2	1	1	3	2
CO2	1	2	3	2	2	1	1	1	1	2	1	1	3	2
CO3	1	1	3	2	2	1	1	1	1	2	1	1	3	2
CO4	1	2	3	1	2	1	1	1	1	2	1	1	3	3
CO5	1	1	3	1	2	1	1	1	1	2	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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THERMAL ENGINEERING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-5-4-05R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To understand the working principles and efficiency improvements in vapour power cycles and boilers.
2. Develop an understanding of steam properties and the ability to determine thermodynamic state points and processes using property charts and tables.
3. Enable students to analyze steam nozzles and steam turbine performance with respect to flow, energy conversion, compounding, and efficiencies.
4. Provide detailed knowledge on internal combustion engines, classification, construction, working principles, and combustion phenomena in SI and CI engines.
5. Equip students with skills to evaluate engine performance parameters, conduct tests, interpret heat balance, and assess losses for real engineering applications.

COURSE CONTENT:**UNIT I: (L-12)**

Steam Power Cycles: Steam Power plant and its components, site selection, Carnot Vapour Power Cycle, Rankine cycle, Rankine Cycle with Reheat, Superheat, and Regeneration, Plant efficiency, Comparison of Carnot and Rankine cycles.

Boilers: Classification Based on Working Principles & Pressures of Operation - L.P & H.P. Boilers – Mountings and Accessories. **Draught:** Classification – Height of Chimney for Given Draught and Discharge, Condition for Maximum Discharge, Efficiency of Chimney – Artificial Draught, Induced and Forced Draught.

UNIT II: (L-12)

Steam Properties: Properties of Steam, Definitions of saturated states; PV, TS, HS Diagrams, P-V-T surface, Principle of increase of entropy; Steam Processes – Constant Volume, Constant pressure – Isothermal, Adiabatic and Hyperbolic Process, Throttling expansion. Identification of states & determination of properties.

UNIT III: (L-12)

Steam Nozzles: Types of nozzles, velocity of steam, discharge through nozzle, critical pressure ratio and condition for maximum discharge, physical significance of critical pressure ratio, and nozzle efficiency.

Analysis of Steam Turbines: Principles and operation – Classification - velocity and pressure compounding of Steam Turbines – Work done – Diagram Efficiency, Effect of Blade friction – Stage Efficiency.


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UNIT IV: (L-12)

I.C. Engines: Definition of Engine and Heat Engine, I.C. Engine Classification, Parts of I.C. Engines, Working of I.C. Engines, Two Stroke & Four Stroke I.C. Engines SI & CI Engines, Valve and Port Timing Diagrams.

Combustion in S.I. Engines: Initiation of combustion, flame velocities, normal and abnormal combustion, knocking combustion, pre-ignition, knock and engine variables in SI engines.

Combustion in C.I. Engines: Various stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl, squish, tumble flow, velocities, swirl measurement, and delay period correlations. Diesel knocks and engine variables in C.I. Engines

UNIT V: (L-12)

Testing and Performance: Parameters of Performance-Engine Power-Engine efficiencies - Measurement of Cylinder Pressure, fuel consumption, Air Intake, Exhaust Gas Composition, Brake Power, Determination of Frictional Losses and Indicated Power, Performance Test, Heat Balance Sheet, and Chart.

TEXT BOOKS:

1. Engineering Thermodynamics by P.K. Nag, Fifth Edition, Tata McGraw-Hill Publishing Co. Ltd, 2013.
2. Engineering Thermodynamics by R. K. Rajput, Third edition, Lakshmi Publications (P) Ltd, 2007.
3. Thermal Engineering by R.K. Rajput, Tenth Edition, Lakshmi Publications (P) Ltd, 2017.
4. Internal Combustion Engines Fundamentals by John B. Heywood, Second Edition, Tata McGraw-Hill Publishing, 2018.
5. Internal Combustion Engines by V. Ganeshan-Tata McGraw-Hill Publishing- Third Edition, 2008.

REFERENCE BOOKS:

1. Fundamentals of Thermodynamics, Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J, Sixth Edition, John Wiley and Sons, 2003.
2. Engineering Thermodynamics, Jones, J. B. and Duggan, R. E, Second Edition, Prentice-Hall of India, 1996.
3. Internal Combustion Engines, K.K. Ramalingam, Third Edition, SciTech Publications, 2018.
4. Internal Combustion Engines, R.K. Rajput, Third Edition, Lakshmi Publications Pvt. Ltd, 2016.
5. Internal Combustion Engine, M. L Mathur and R. P. Sharma, Eighth edition, Dhanpat Rai Publications, 2016


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COURSE OUTCOMES:

After successful completion of the course, the student will be able to:

1. Explain the working and efficiency improvement techniques of vapour power cycles and boilers.
2. Interpret steam properties and determine thermodynamic states using steam charts and tables.
3. Analyze flow through steam nozzles to determine critical pressure ratio, discharge, and nozzle efficiency and Evaluate steam turbine operation, apply compounding principles, and compute stage and diagram efficiencies.
4. Describe the construction, working, combustion stages, and knocking phenomena in SI and CI engines.
5. Conduct engine performance tests, measure key parameters, prepare heat balance sheets, and analyze energy losses.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2	2	2	1	2	1	1	1	1	1	3	2
CO2	3	3	2	2	2	1	2	1	1	1	1	1	3	2
CO3	3	3	2	2	2	1	2	1	1	1	1	1	3	3
CO4	3	3	2	2	3	1	3	1	1	1	1	1	3	3
CO5	3	3	2	3	3	1	2	1	1	2	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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PROFESSIONAL ETHICS IN ENGINEERING**Credits: 0****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
IV	2-0-0	7-1-5-09R25	ME

COURSE OBJECTIVES:

1. To understand the core values that shape a professional character, such as integrity, work ethic, and civic virtue.
2. To create awareness about engineering ethics and theories of moral development (Kohlberg & Gilligan).
3. To instil a sense of responsibility regarding safety, risk assessment, and the experimental nature of engineering projects.
4. To educate students on their rights and responsibilities in a workplace, including Intellectual Property Rights (IPR) and confidentiality.
5. To broaden the perspective on global issues, such as environmental ethics, computer ethics, and the role of engineers as managers and consultants.

UNIT I**HUMAN VALUES**

Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self Confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

UNIT II**ENGINEERING ETHICS**

Senses of Engineering Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles – Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

UNIT III**ENGINEERING AS SOCIAL EXPERIMENTATION**

Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law.


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UNIT IV**SAFETY, RESPONSIBILITIES AND RIGHTS**

Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.

UNIT V**GLOBAL ISSUES**

Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership – Code of Conduct – Corporate Social Responsibility.

COURSE OUTCOMES:

1. Apply holistic human values, such as integrity, honesty, and empathy, to their personal and professional lives to maintain harmony.
2. Apply ethical theories (like Utilitarianism or Duty ethics) to resolve moral dilemmas and distinguish between ethical and unethical professional behavior.
3. Analyze engineering projects as social experiments, demonstrating an understanding of codes of ethics and the need for responsible experimentation.
4. Assess safety and risk in engineering practices and defend professional rights and responsibilities, including intellectual property and whistleblowing.
5. Evaluate global challenges—such as environmental degradation, computer ethics, and weapons development—and apply ethical principles to multinational corporate scenarios.

TEXT BOOKS:

1. Mike W. Martin and Roland Schinzinger, Ethics in Engineering, Tata McGraw Hill, New Delhi, 2003.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, Engineering Ethics, Prentice Hall of India, New Delhi, 2004.


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REFERENCES:

1. Charles B. Fleddermann, —Engineering Ethics, Pearson Prentice Hall, New Jersey, 2004.
2. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, —Engineering Ethics – Concepts and Cases, Cengage Learning, 2009.
3. John R Boatright, —Ethics and the Conduct of Business, Pearson Education, New Delhi, 2003
4. Edmund G Seebauer and Robert L Barry, —Fundamentals of Ethics for Scientists and Engineers, Oxford University Press, Oxford, 2001.
5. Laura P. Hartman and Joe Desjardins, —Business Ethics: Decision Making for Personal Integrity and Social Responsibility Mc Graw Hill education, India Pvt. Ltd., New Delhi, 2013.
6. World Community Service Centre, Value Education', Vethathiri publications, Erode, 2011.

PO& PSO	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)		PSO (1)	PSO (2)
CO															
CO1	1	1	1	1	1	2		3	3	1	1	3		1	2
CO2	1	1	1	1	1	2		3	2	1	1	2		1	1
CO3	1	1	1	1	1	3	1	3	2	1	1	2		2	1
CO4	1	1	1	1	1	3		3	2	1	1	2		2	2
CO5	1	1	1	1	1	2	3	3	1	1	1	2		1	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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FLUID MECHANICS AND HYDRAULIC MACHINERY LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	0-0-3	7-5-4-R25 P1	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To determine the coefficient of discharge in flow measuring devices.
2. To determine the coefficient of different losses in pipe flow.
3. To determine Specific Speed and draw the performances Characteristic curves of pumps.
4. To determine on the selection of hydraulic turbines for practical purposes and also able to prepare prototype models.
5. To determine the selection of pumps for practical purposes.

List of Experiments**CONTENTS: FLOW MEASUREMENT**

1. Calibration of Small Orifice
2. Calibration of Venturi Meter
3. Calibration of Orifice Meter
4. Calibration of Triangular Notch

HEAD LOSSES IN PIPES

1. Determination of Friction factor of the pipe material
2. Determination of Head Loss coefficient due to sudden contraction
3. Determination of Head Loss coefficient due to Gate valve in a pipe line

HYDRAULIC MACHINES

1. Characteristic curves of 0.8 KW two stage centrifugal pump
2. Characteristic curves of 5.5 KW variable speed centrifugal pump

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Able to gain basic knowledge on Fluid Statics, Fluid Dynamics, closed conduit flows.
2. Ability to analyze fluid flow problems with the application of the momentum and energy equations and compute drag and lift coefficients using the theory of boundary layer flows.
3. Able to know the applications of momentum principles in all power plants.
4. Acquire knowledge on the selection of hydraulic turbines for practical purposes and also able to prepare prototype models.
5. Able to have thorough knowledge on selection of pumps for practical purposes.


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CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	0	1	2	1	1	3	1	2	3
CO2	3	2	1	0	0	0	1	2	1	1	2	1	2	3
CO3	2	2	0	0	1	0	1	1	0	2	1	3	2	3
CO4	2	2	0	0	0	0	1	1	0	2	1	3	2	3
CO5	1	2	3	0	1	0	1	1	0	2	1	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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MANUFACTURING PROCESSES LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	0-0-3	7-5-4-R25 P2	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. **To understand** the working principles, construction, and applications of basic machine tools such as lathe, shaper, milling, drilling, and welding machines.
2. **To develop skills** in performing fundamental machining operations like turning, shaping, milling, threading, drilling, and tapping as per given specifications.
3. **To apply knowledge** of cutting tools, work holding devices, and machining parameters for accurate and safe manufacturing practices.
4. **To fabricate components** with required dimensional accuracy and surface finish using appropriate machining and welding processes.
5. **To practice safety norms**, proper tool handling, and workshop discipline while working individually and in teams.

COURSE CONTENT:

Hands-on training in lathe, shaper, milling, threading, drilling, boring, tapping, and welding operations for manufacturing basic mechanical components with emphasis on accuracy, safety, and proper tool usage.

LIST OF EXPERIMENTS:**I LATHE**

1. Step Turning
2. Taper Turning with Knurling
3. V Threading

II SHAPER

4. Making Square prism on Shaper
5. Slot Cutting with Shaping Machine

III MILLING MACHINE

6. Rectangular Slot Cutting on Vertical Milling Machine
7. Hexagonal Cutting on Horizontal Milling Machine
8. Spur Gear cutting on Milling


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IV THREADING

9. Square Threading
10. Double Start V Threading
11. Drilling, Boring and Tapping

V WELDING

12. Joining of Two Metal Work Pieces with Arc Welding or Gas Welding

TEXT BOOKS:

1. **Raghuwanshi, B.S.** – *Workshop Technology (Vol. I & II)*, Dhanpat Rai & Co.
2. **Hajra Choudhury, S.K., Hajra Choudhury, A.K. & Roy, N.** – *Elements of Workshop Technology (Vol. I & II)*, Media Promoters & Publishers.
3. **Chapman, W.A.J.** – *Workshop Technology*, Edward Arnold Publishers.

REFERENCE BOOKS:

1. **Nagpal, G.R.** – *Engineering Workshop Practices*, Khanna Publishers.
2. **Kalpakjian, S. & Schmid, S.** – *Manufacturing Processes for Engineering Materials*, Pearson Education.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. The manufacturing process lab outcomes have led to increased efficiency in production, reducing operational costs and production time.
2. Through rigorous testing and analysis, the lab has implemented quality control measures that ensure the production of consistently high-quality products.
3. The lab outcomes have identified opportunities for waste reduction and sustainability improvements, minimizing environmental impact.
4. Continuous research and experimentation have resulted in optimized manufacturing processes, leading to higher output and lower resource consumption.
5. The lab's findings have also contributed to safer working environments by identifying and mitigating potential hazards in the manufacturing process.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	2	2
CO2	2	3	2	1	1	1	1	1	1	1	1	1	2	1
CO3	2	3	3	1	2	1	1	1	1	1	1	1	2	1
CO4	2	2	3	1	2	1	1	1	1	1	1	1	2	1
CO5	1	1	1	1	1	1	1	1	3	2	1	1	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

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FUELS AND LUBRICANTS LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	0-0-3	7-5-4-03R25P3	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To understand the fundamental properties of fuels.
2. To familiarize students with the operation and handling of standard fuel testing instruments.
3. To develop the ability to perform experiments safely and accurately.
4. To analyse experimental data and interpret results.
5. To train students in interpreting experimental data, plotting performance graphs, and preparing technical reports with analytical reasoning.

List of experiments:

1. Determination of Flash and Fire points of Liquid fuels/Lubricants using Abel's Apparatus.
2. Determination of Flash and Fire points of Liquid fuels/Lubricants using: Pensky Martens Apparatus.
3. Determination of Viscosity of Liquid lubricants and Fuels using: Saybolt Viscometer
4. Determination of Viscosity of Liquid lubricants and Fuels using: Redwood Viscometer
5. Test on Aniline Point Apparatus
6. Performance Test on a Blower
7. Determination of Calorific value: Solid/Liquid/ fuels using the Bomb Calorimeter.
8. ASTM Distillation Test Apparatus.
9. Cloud and Pour Point Apparatus.
10. Study of Boilers


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COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Identify and explain various fuel properties and their significance in engineering applications.
2. Perform experiments using viscometers, flash & fire point apparatus, bomb calorimeter, distillation and aniline point apparatus with proper procedures and safety.
3. Analyse and interpret experimental data to determine fuel characteristics such as viscosity, calorific value, flash point, cloud & pour point, and density.
4. Evaluate fuel quality and performance (e.g., blower performance, fuel suitability) based on test results and standards.
5. Demonstrate teamwork, laboratory discipline, and effective communication through report preparation and presentation of experimental results.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	1	1
CO2	2	2	1	2	3	1	1	2	1	1	1	1	1	1
CO3	2	3	1	3	2	1	1	1	1	1	1	2	1	1
CO4	2	3	1	3	2	1	2	1	1	1	1	2	1	1
CO5	1	1	1	1	1	1	1	2	3	3	2	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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FINITE ELEMENT ANALYSIS LAB**Credits: 2****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	1-0-2	7-5-4-R25S1	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The vital learning objectives of this course are

1. To introduce the basic steps involved in Finite Element Analysis (FEA) and use of Matlab functions for FEA of spring assemblage systems – Spring element as Finite Element
1. To develop basic equations of a linear bar element and to use Matlab functions for FEA of a bar structure by a linear bar element
2. To write basic equations of a quadratic bar element and to use Matlab functions for FEA of a bar structure by a quadratic bar element
1. To formulate basic equations of a plane truss element and to use Matlab functions for FEA of a structure by a plane truss element.
2. To inculcate knowledge about two – dimensional beam element and to analyse the given beam structure by Matlab functions of a beam element.

UNIT – I

Introduction –Steps of the Finite Element Analysis (FEA) – MATLAB Functions for FEA – Overview of MATLAB – The spring Element Basic Equations – MATLAB Functions Used – Practice Exercises

UNIT – II

The Linear Bar Element – Basic Equations – MATLAB Functions Used – Practice Exercises

UNIT – III

The Quadratic Bar Element – Basic Equations – MATLAB Functions Used – Practice Exercises

UNIT – IV

The Plane Truss Element – Basic Equations – MATLAB Functions Used – Practice Exercises

UNIT – V

The Beam Element – Basic Equations – MATLAB Functions Used – Practice Exercises


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TEXTBOOKS

1. Fundamentals of Finite Element Analysis by David V. Hutton
2. Concepts and Applications of Finite Element Analysis by Robert D. Cook, David S. Malkus and Michael E. Plesha
3. MATLAB Guide to Finite Elements – An interactive Approach by Peter I. Kattan
4. A first course in the Finite Element Method by Daryl L. Logan
5. An Introduction to Finite Element Method by J.N. Reddy

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Understand the basic steps involved in Finite Element Analysis (FEA) and to formulate basic equations of various types of finite elements for the analysis of elastic structural members including spring assemblage systems.
1. Acquaint with linear bar elements and to write Matlab functions for the analysis of linear bar structures
2. Analyze the bar structures by Matlab functions of quadratic bar elements on Matlab platform.
3. Develop basic equations of plane truss element and to write the corresponding Matlab functions for the analysis of plane truss elastic members.
4. Distinguish between one – dimensional and two – dimensional elements by grasping the concept of beam element and to analyze the beam structures by Matlab functions of beam element.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	2	2	1	1	1	1	2	1	1	3	2
CO2	2	1	3	2	3	1	1	1	1	2	1	1	3	2
CO3	2	3	2	2	3	1	1	1	1	2	1	1	3	2
CO4	2	1	3	2	3	1	1	1	1	2	1	1	3	3
CO5	2	3	1	2	3	1	1	1	1	2	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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ENVIRONMENTAL SCIENCE**Credits: 0****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
IV	2-0-0	7-5-4-03R25M1	ME

Course Educational Objectives (CEOs):

1. Introduce the scope and importance of environmental resources and their sources.
2. Impart knowledge on Ecosystem and Biodiversity.
3. Impart knowledge on causes and consequences of Environmental pollution its Global effects.
4. Familiarize with environmental issues and their management.
5. Outline different social issues and the guidelines formulated for protection of environment.

UNIT I**Environmental Studies and Natural Resources**

Definition, Scope and importance of Environment, Environmental studies, Need for public awareness

Components of Environment- Atmosphere, Hydrosphere, Lithosphere.

Renewable and Non-Renewable Resources and associated problems

Water resources: Use and over utilization of surface and ground water, floods, drought, conflicts over water, dams benefits and problems.

Forest resources: Use and over exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.

Land resources: Land as a resource, land degradation, Man induced landslides, soil erosion and desertification.

Mineral resources: Use and overexploitation, Environmental effects of extracting and using mineral resources, case studies.

Food resources: World food problems, changes caused agriculture and overgrazing, effects of modern agriculture, fertilizer – pesticide problems, water logging, salinity, Case studies.

Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Role of an individual in conservation of natural resources.

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UNIT II**Ecosystem and Biodiversity**

Ecosystem - Concept of an ecosystem.

Structure and functions of an ecosystem.

Producers, consumers and decomposers.

Energy flow in the ecosystem.

Ecological succession.

Food chains, food webs and ecological pyramids.

Introduction, types, characteristic features, structure and function of the following ecosystem.

(a) Forest ecosystem. (b) Grassland ecosystem

(c) Desert ecosystem. (d) Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity and its conservation:

Definition, genetic species and ecosystem diversity.

Biogeographically classification of India.

Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values.

Biodiversity at global, National and local levels.

India as a mega-diversity nation.

Hot-spots of biodiversity.

Threats to biodiversity: habitat loss, poaching of wildlife, man – wildlife conflicts.

Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

UNIT – III**Environmental pollution and Global Effects**

Definition, Causes, Effects, and control measures of (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards

Solid waste Management: Causes, effects and control measures of urban and industrial wastes.

Role of an individual in prevention of pollution.

Pollution case studies.

Disaster management: Floods, earthquakes, cyclone, landslides, Tsunami.

Climate change-Global warming, Acid rain, Ozone depletion.

UNIT – IV**Environment Issues and Management**

Environment and Human health – Epidemic diseases, HIV/AIDS, Aviation Flue, Water Borne Diseases.

Environmental Impact Assessment, Sustainable Development, Clean Production and Clean Development Mechanisms



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Environment Legislation: Environmental Protection Act, Water Act, Air Act, Wild Life Protection Act, Forest Conservation Act, Public Liability & Insurance Act, Issues involved in Enforcement of Environmental legislation.

UNIT – V

Social Issues and the Environment

Population growth, Population Explosion, Population Control, Women and Child welfare. Urbanization, Industrialization, Development projects, Resettlement and Rehabilitation of people – Problems concerned, Case studies.

Consumerism and Waste Products Conservation, Public Awareness, Water Conservation, Rain water harvesting, watershed management, Wasteland reclamation, Human Rights, Value education, Environmental ethics- Issues and possible solution.

Role of information Technology in Environment and Human Health.

Text Books / Reference Books :

1. AnubhaKaushik& C P Kaushik, Environmental studies, New age International Publishers, 2008
2. Benny Joseph, Environmental studies, Tata McGraw-Hill Publishers, 2005
3. M Chandra Sekhar, Environmental Science, Hi-Tech Publishers, 2004
4. Keerthinarayana and Daniel Yesudian, Principles of Environmental Sciences and Engineering , Hi-Tech Publishers, 2005
5. AmalK.Datta, Introduction to Environmental Science and Engineering, Oxford & IBH Publishing Co.Pvt.Ltd, 2000
6. SanthoshkumarGarg,RajeshawriGarg and RajniGarg, Ecological and Environmental studies, Khanna publishers, 2006
7. Gilbert M, Introduction to Environmental Engineering and Science, Masters Publication by Prentice –Hall of India Private Ltd., 1991
8. William P Cunningham and Mary Ann Cunningham, Principles of Environmental Science, Tata McGraw Hill Publishing Co.Ltd, 2002


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Course Outcomes (Cos):

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

1. Acquire knowledge in diverse components of environment and natural resources.
2. Understand ecosystem and biodiversity and its conservation methods.
3. Identify and resolve the issues related to sources of different types of pollution and its global effects
4. Provide solutions to individuals, industries and government for sustainable development of natural resources
5. Apply environmental ethics in resolving social issues for protection of diversified ecosystems.

PO& PSO /CO	PO(1)	PO(2)	PO(3)	PO(4)	PO(5)	PO(6)	PO(7)	PO(8)	PO(9)	PO(10)	PO(11)	PO(12)	PSO(1)	PSO(2)
CO1						3		3	2	1	2	3	3	2
CO2								3	2	1	2	3	3	2
CO3								3	2				3	2
CO4								3	2				3	1
CO5								3	2				3	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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B. Tech. (Mechanical Engineering)
Semester V (Third Year)

Code		Category	Course Title	Hours/Week			Total	Credits	Marks		
Department	University			L	T	P			CIE	SEE	Total
ME 5501C	7-5-5-01R25	ME-PC	Design of Machine Elements	3	0	0	3	3	40	60	100
ME 5502C	7-5-5-02R25	ME-PC	Metrology and Instrumentation	3	0	0	3	3	40	60	100
ME 5503C	7-5-5-03R25	ME-PC	Heat Transfer	3	0	0	3	3	40	60	100
ME5504C	7-5-5-04R25	ME-PC	Operations Research	3	0	0	3	3	40	60	100
ME 5505E	7-5-5-R25E1	ME-PE	Professional Elective- I	3	0	0	3	3	40	60	100
ME 5506E	7-5-5-R25E2	ME-PE	Professional Elective- II	3	0	0	3	3	40	60	100
ME 5507L	7-5-5-R25P1	ME-PC	Machine Tools Lab	0	0	3	3	1.5	40	60	100
ME 5508L	7-5-5-R25P2	ME-PC	Internal Combustion Engines Lab	0	0	3	3	1.5	40	60	100
ME 5509S	7-5-5-R25S1	ME-SC	Advanced Manufacturing Processes Lab	1	0	2	3	2	40	60	100
ME 5510I	7-0-5-R25CS	ME-PW	Community Service Project Internship	0	0	0	0	2	100	0	100
ME 5511K	7-5-5-R25MK	ME-IK	Ancient Indian Metallurgy & Material Science (IKS- Mandatory)	2	0	0	2	0	100	0	100
TOTAL				21	0	8	29	25.0	560	540	1100
Students shall ensure that IKS MOOKS and IKS Mandatory courses are not same either in title and/or in syllabi.											



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MECHANICAL ENGINEERING

PROFESSIONAL ELECTIVE COURSES

Professional Elective - I (V Sem)	7-5-5-R25E11	Non-conventional Energy Sources
	7-5-5-R25E12	Welding Technology
	7-5-5-R25E13	Mechanical Vibrations
	7-5-5-R25E14	Product Design and Development
	7-5-5-R25E15	Biomedical Engineering
	7-5-5-R25E16	Geometric Modelling for CAD
Professional Elective – II (V Sem)	7-5-5-R25E21	Advanced Manufacturing Processes
	7-5-5-R25E22	Composite Materials
	7-5-5-R25E23	Design for Manufacturing and Assembly
	7-5-5-R25E24	Value Engineering
	7-5-5-R25E25	Fuel Cell Technology
	7-5-5-R25E26	Robotics
Professional Elective – III (VI Sem)	7-5-6-R25E11	Analysis and Control of Production Systems
	7-5-6-R25E12	Introduction to Drone Technology
	7-5-6-R25E13	Industrial Safety
	7-5-6-R25E14	Introduction to Turbo Machinery
	7-5-6-R25E15	Tool Design
	7-5-6-R25E16	Oil Hydraulics and Pneumatics
Professional Elective – IV (VI Sem)	7-5-6-R25E21	Power Plant Engineering
	7-5-6-R25E22	Refrigeration and Air-conditioning
	7-5-6-R25E23	Quality control and Reliability Engineering
	7-5-6-R25E24	Energy Management and Audit
	7-5-6-R25E25	Alternative fuels
	7-5-6-R25E26	Data Science for Mechanical Engineers
	7-0-6-R25CE1	Introduction to Semiconductor Manufacturing
Professional Elective – V (VII Sem)	7-5-7-R25E11	Additive Manufacturing
	7-5-7-R25E12	Mechatronics
	7-5-7-R25E13	Supply Chain Management
	7-5-7-R25E14	Maintenance Engineering and Management
	7-5-7-R25E15	Finite Element Method
	7-5-7-R25E16	Tribology
Professional Elective – VI (VII Sem)	7-5-7-R25E21	Project Management
	7-5-7-R25E22	Hybrid Electric Vehicles
	7-5-7-R25E23	Flexible Manufacturing Systems
	7-5-7-R25E24	Design and Analysis of Experiment
	7-5-7-R25E25	Artificial Intelligence and Machine Learning
	7-5-7-R25E26	Lean Manufacturing and Six Sigma



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DESIGN OF MACHINE ELEMENTS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-01R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Understand the manufacturing considerations in design and analyze components under static, thermal, and residual stresses using appropriate failure theories.
2. Analyze and design components subjected to fluctuating and fatigue loading conditions using established design criteria.
3. Apply design principles to threaded fasteners and bolted joints under static and dynamic loading for strength, rigidity, and reliability.
4. Design welded joints and shafts considering strength, torsional rigidity, eccentric loading, and applicable design codes.
5. Design mechanical joints and couplings such as keys, splines, and couplings, ensuring safe power transmission and rigidity under practical working conditions.

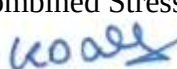
COURSE CONTENT:*Significance of Theory of Machines, Classification.***UNIT I:****(L-10)**

MANUFACTURING CONSIDERATIONS IN DESIGN: Selection of Manufacturing Method, Design Considerations of Castings, Design Considerations of Machined Parts, Design Considerations of Welded Assemblies, Design for Manufacture and Assembly (DFMA), Tolerances, Types of Fits, BIS System of Fits and Tolerances, Selection of Fits.

Design against static Load: Modes of Failure, Factor of Safety, Stress-strain relationships, shear stress and shear strain, Stresses Due To Bending Moment, Stresses Due To Torsional Moment, Eccentric Axial Loading, Principal Stresses, Theories of Elastic Failure, Maximum Principal Stress Theory, Maximum Shear Stress Theory, Distortion-Energy Theory, Selection and Use of Failure Theories, Basics of Fracture Mechanics, Thermal Stresses, Residual Stresses.

UNIT II:**(L-10)****DESIGN AGAINST FLUCTUATING LOAD:**

Stress Concentration, Stress Concentration Factors, Reduction of Stress Concentration, Fluctuating Stresses, Fatigue Failure, Endurance Limit, Low-cycle and High-cycle Fatigue, Notch Sensitivity, Endurance Limit-Approximate Estimation, Reversed Stresses-Design for Finite and Infinite Life, Cumulative Damage in Fatigue, Soderberg and Goodman Lines, Modified Goodman Diagrams, Gerber Equation, Fatigue Design under Combined Stresses.


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UNIT III: (L-10)**DESIGN OF FASTENERS THREADED JOINTS:**

Threaded Joints, Basic Types of Screw Fastening, Cap Screws, Setscrews, Bolt of Uniform Strength, Locking Devices, Terminology of Screw Threads, ISO Metric Screw Threads, Bolted Joint-Simple Analysis, Eccentrically Loaded Bolted Joints in Shear, Eccentric Load Perpendicular to Axis of Bolt, Eccentric Load on Circular Base, Torque Requirement for Bolt Tightening, Dimensions of Fasteners, Design of Turnbuckle, Elastic Analysis of Bolted Joints, Bolted Joint under Fluctuating Load.

UNIT IV: (L-10)

WELDED JOINTS: Types of welded joints; stresses in butt and filler welds; strength of welded joints; Eccentric loaded welded joints; weld joint subject to bending moment and fluctuating forces; welding symbols; welded inspection.

DESIGN OF SHAFTS:

Shaft Design on Strength Basis, Shaft Design on Torsional Rigidity Basis, ASME Code for Shaft Design, Design of Hollow Shaft on Strength Basis, Design of Hollow Shaft on Torsional Rigidity Basis, Flexible Shafts.

UNIT V: (L-10)**DESIGN OF KEYS:**

Saddle Keys, Sunk Keys, Feather Key, Woodruff Key, Design of Square and Flat Keys, Design of Kennedy Key, Splines.

DESIGN OF COUPLINGS:

Muff Coupling, Design Procedure for Muff Coupling, Clamp Coupling, Design Procedure for Clamp Coupling, Rigid Flange Couplings, Design Procedure for Rigid Flange Coupling, Bushed-pin Flexible Coupling, Design Procedure for Flexible Coupling, Design for Lateral Rigidity, Critical Speed of Shafts, Area Moment Method.

TEXT BOOKS:

1. DESIGN OF MACHINE ELEMENTS, VB BHANDARI, Third Edition, McGraw Hill International.
2. Shigley J. E and Mischke, C.R.: Mechanical Engineering Design, Fifth Edition, McGraw Hill International, 1989.
3. Deutschman D. Michels, W.J. and Wilson, C.E, Machine Design Theory and Practice, MacMillan, 1992
4. Juvinal, R.C., Fundamentals of Machine component design, John Wiley, 1994



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REFERENCE BOOKS:

1. Spottes, M.F., Design of Machine Elements, Prentice – Hall India, 1994
2. R.L. Norton, Mechanical Design – An integrated Approach, Prentice Hall, 1998

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Apply principles of manufacturing considerations, tolerances, and theories of failure to design machine elements against static and thermal loads.
2. Evaluate fatigue life and design mechanical components subjected to fluctuating loads using Soderberg, Goodman, and Gerber criteria.
3. Analyze and design threaded fasteners and bolted joints subjected to eccentric and fluctuating loads with proper torque and strength requirements.
4. Design welded joints and shafts considering bending, torsion, eccentric loading, and code-based design practices.
5. Design and select suitable keys, splines, and couplings for power transmission systems while ensuring rigidity and reliability under operating conditions.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	2	2	1	1	1	1	1	1	1	2	3	2
CO2	3	3	3	2	2	1	1	1	1	1	1	2	3	2
CO3	3	2	3	2	2	1	1	1	2	2	1	2	3	2
CO4	3	2	3	2	2	1	1	1	2	2	1	2	3	3
CO5	3	2	3	2	2	1	1	1	2	2	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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METROLOGY AND INSTRUMENTATION**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-02R25	ME

Pre-Requisites: This course covers the fundamentals of dimensional measurement, limits and fits, surface finish, screw threads, alignment testing, and CMM. It also introduces sensors, transducers, pressure and temperature measurement, calibration, and error analysis. Emphasis is on accuracy, instrument selection, and quality control in engineering applications.

COURSE OBJECTIVES: The main learning objective of this course is

1. Able to study the Linear measurement and Angular measurements.
2. Able to study the limits and fits and optical measuring methods.
3. Able to study Screw thread and roughness of surface.
4. Able to study the Alignment test and CMM
5. Able to study the different setups for measuring Pressure and Temperature.

COURSE CONTENT:**UNIT I:****(L-8)**

Concept of measurement: Introduction to Metrology, Need for high precision measurements, Terminologies in Measurement, Precision, accuracy, sensitivity, calibration. Errors in Measurement, types of errors.

Basic standards of length: Line standard, End standards, Various Shop floor standards.

Linear Measurement: Slip gauges, wringing, grades, Surface plate, Dial indicators, Height gauges and Vernier callipers.

Comparators: Mechanical, electrical, optical and pneumatic.

Angular Measurement: Bevel protractor; Sine Bar, principle and use of sine bar, Angle gauges. Spirit level; Angle Dekker, Clinometers.

UNIT II:**(L-12)**

Limits and Limit gauges: Making to suit, selective assembly, systems of limits and fits, Types of fits, Hole basis system and Shaft basis system. Standard systems of limits and fits, Shaft and Hole system; Tolerance, allowance and deviation (as per BIS). Simple problems on tolerance and allowance, shaft and hole system.

Limit Gauges: GO and NO GO gauges, types of limit gauges. Gauge design, Taylor's principle of gauging Gauge tolerance, disposition of gauge tolerance, wear allowance.

Optical Measuring Instruments: Benefits of using light waves as standards, Monochromatic light, Principle of Interference. Interference band using optical flat, application in surface measurement. Interferometers, NPL flatness interferometer.



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UNIT III:**(L-10)**

Screw thread measurement: Screw thread terminology, Measurement of major diameter, Measurement of minor or root diameter. Measurement of pitch, Measurement of effective diameter with two wire method and three wire method. Measurement of flank angle and form by profile projector and microscope. **Measurement of surface texture:** Meaning of surface texture, roughness, and waviness; Analysis of surface traces, peak to valley height, R.M.S. value, Centre Line Average and Ra value, Rt, Rz etc. Methods of measuring surface roughness, Stylus probe, Tomlinson surface meter, Talysurf, Terms used in surface roughness measurement, sampling length and evaluation length.

Interference method for measuring surface roughness: using optical flat and interferometers. Autocollimator, principle and use of autocollimator.

UNIT IV:**(L-8)**

Machine tool metrology: Alignment testing of machine tools like lathe, milling machine, drilling machine.

Coordinate Measuring Machine (CMM): Introduction to CMM, Components and construction of CMM. Types of CMM, Advantages and application of CMM, CMM probes, types of probes, contact probes and non-contact probes,

Machine Vision: Introduction to machine vision, functions, applications and advantages of machine vision. Steps in machine vision.

UNIT V:**(L-8)**

Measurement of Temperature: Classification ranges, various principles of measurement, expansion, electrical resistance, thermistor, thermocouple.

Measurement of pressure: Classification, Manometers, bourdon pressure gauge, bellows, diaphragm gauges.

Transducers :- Classification of transducers. LVDT –Principle, applications, advantages and limitations

TEXT BOOKS:

1. R.K. Jain -Engineering Metrology and Measurements, Khanna Publishers, 19th Edition ,2022
2. Ernest O. Doebelin & Dhanesh N. Manik -Measurement systems: Application and Design, Mc Graw Hill Education, 6th Edition.2017
3. Alan S. Morris & Reza Langari- Measurement and Instrumentation: Theory and Application, Academic Press (Elsevier) ,2nd Edition 2016
4. D.S. Kumar – Mechanical Measurements and Control, Metropolitan book Co,3rd Edition,2011
5. I.C.Gupta- Engineering Metrology,Dhanpat Rai &sons publications(p) Ltd. 3rd Edition,2020



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REFERENCE BOOKS:

1. R.S. Sirohi & H.C. Radha Krishna – Mechanical Measurements, New age international publishers, 3rd Edition, 2013
2. B.C. Nakra & K.K. Chaudhry – Instrumentation, Measurement and Analysis, McGraw Hill Education, 4th Edition, 2018
3. Thomas G. Beckwith, Roy D. Marangoni & John H. Lienhard- Mechanical measurements. Pearson Education, 6th Edition, 2007
4. K.J. Hume – Engineering Metrology

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Students will be able to analyse the Linear measurement and Angular measurements.
2. Students will be able to perform the limits and fits and optical measuring methods.
3. Students will be able to analyse Screw thread and roughness of surface.
4. Students will be able to perform the Alignment test and CMM
5. Students will be able to understand the different setups for measuring Pressure and Temperature.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PS O1	PSO2
CO1	3	2	1	2	1	1	1	1	1	1	1	1	1	1
CO2	3	2	1	2	1	1	1	1	1	1	1	1	1	1
CO3	3	2	2	3	2	1	1	1	1	1	1	1	1	1
CO4	3	2	3	2	3	1	1	1	1	1	1	1	1	1
CO5	3	2	2	2	2	1	1	1	1	1	1	1	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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HEAT TRANSFER**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-4-03R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To impart fundamental knowledge of heat transfer mechanisms and governing laws.
2. To enable students to analyse one-dimensional and multidimensional conduction systems under steady and transient conditions.
3. To develop an understanding of forced and natural convection heat transfer in various flow configurations.
4. To explain radiative heat transfer and its significance in thermal systems.
5. To introduce heat exchanger design concepts and performance evaluation methods.

COURSE CONTENT:**UNIT I:****(L-12)**

General Modes of Heat Transfer: Basic modes of Heat Transfer, Basic laws of Heat Transfer, Applications of Heat Transfer, Fourier law of heat conduction, Newton's law of Cooling Basic equations, Coefficient of thermal conductivity convective, Heat transfer coefficient, Stephan Boltzmann constant, Overall heat transfer coefficient.

Conduction in steady state

Theory of heat conduction, Heat flow through plane wall and cylinder with Variable Thermal conductivity, Conduction through slabs, cylinders and spheres, Concept of thermal resistance, critical thickness insulation, logarithmic mean area, concept of shape factor, one dimensional steady state conduction with heat addition.

UNIT II:**(L-12)**

Conduction : Conduction in unsteady state periodic and a periodic temperature variance, infinite semi and infinite solids general equations for conduction in unsteady state, lumped capacitance method, transfer heat flow in semi- infinite solid, convection boundary conditions – use of Grober / Heisler charts.

Heat transfer through extended surfaces: Theory of fins, fins of uniform cross-sectional area, Analysis of Long Fin and Short fin with insulated tip, heat transfer calculations, fin efficiency, fin effectiveness.

UNIT III:**(L-2)**

Radiation: Introduction, Applications of Radiation, Nature of radiation, Emissive Power-Absorption, Reflection and Transmission, concept of black body, gray body, Planck's Law, Stephan Boltzmann law, Kirchhoff's law, Radiation shape factor relations, Heat exchange between black bodies, Heat exchange between non-black bodies, introduction to radiation network analysis, Radiation shields.

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UNIT IV:**(L-12)****Convection:**

Heat transfer due to free convection: Introduction, Applications, Free convection heat transfer on a vertical flat plate, Empirical correlations for vertical plates and cylinders, horizontal plates and cylinders, Natural convection cooling in electronic equipment, heat pipe.

Heat transfer due to forced convection: Introduction, Applications, Principles of convection, The boundary layer concept-The velocity and Thermal boundary layer, Laminar boundary layer on a flat plate thermal boundary layer, empirical relations, laminar and turbulent flows, heat transfer in laminar flow over a flat plate, heat transfer in turbulent flows, relations between fluid friction and heat transfer, heat transfer in laminar tube flow, turbulent flow in pipes, flow across cylinders and spheres.

UNIT V:**(L-12)**

Heat Exchangers: Introduction, Classification of heat exchangers, overall heat transfer coefficient, Fouling factors, LMTD method of Heat exchanger analysis, effectiveness of heat exchangers, NTU method, Compact heat exchangers, different considerations.

TEXT BOOKS:

1. Incropera, F.P., Dewitt, D. P., Fundamentals of Heat & Mass Transfer, Eighth edition, 2018, John Wiley & Sons.
2. J.P. Holman, Heat Transfer, Tenth edition, 2010, McGraw-Hill Book Company, New York.
3. [R.C. Sachdeva](#), Fundamentals of Engineering Heat and Mass Transfer (SI Units), Fifth edition, 2017, New Age International.
4. [Yunus A. Cengel Dr.](#), [Afshin J. Ghajar](#), Heat And Mass Transfer, Sixth edition, 2020, Tata McGraw-Hill Publishing.

REFERENCE BOOKS:

1. K. N. Seetharam & T.R. Seetharam, Fundamentals of Heat and Mass Transfer, Eighth edition 2018, John Wiley & Sons.
2. M.M. Rathor, Engineering Heat and Mass Transfer, Second edition, 2011, Laxmi Publications Pvt. Ltd
3. Heat and Mass Transfer, Dr. S. Senthil Kumar, Standard edition, 2017, AR Publishers.
4. C.P. Kodandaraman, Fundamentals of Heat & Mass Transfer, Third edition, 2006, New Age International.
5. R.K. Rajput, Heat Transfer, Fifth edition 2012, S Chand Company Ltd.



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COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Explain the fundamental mechanisms of conduction, convection, and radiation heat transfer.
2. Analyse one-dimensional unsteady heat conduction problems using analytical methods.
3. Examine radiative heat exchange between surfaces and apply radiation network analysis.
4. Evaluate heat transfer coefficients for forced and natural convection flows.
5. Design and assess the performance of heat exchangers for industrial applications.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	3	1
CO2	3	3	2	2	1	1	1	1	1	1	1	2	3	2
CO3	3	3	3	2	1	1	1	1	1	1	1	2	3	2
CO4	3	3	2	2	1	1	1	1	1	1	1	2	3	2
CO5	3	3	3	2	2	1	1	1	1	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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OPERATIONS RESEARCH**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-04R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Understand the fundamental concepts, characteristics, and phases of Operations Research and to formulate and solve linear programming problems using appropriate methods.
2. Develop the ability to formulate and solve transportation, assignment, and travelling salesman problems for optimal resource allocation.
3. Analyze and solve sequencing and replacement problems for effective scheduling and maintenance decisions.
4. Comprehend the principles of game theory and inventory models for strategic and cost-effective decision-making in competitive and operational environments.
5. Apply network analysis and queuing models for effective project planning, control, and service optimization.

COURSE CONTENT:**UNIT I:****(L-12)****INTRODUCTION:** Definition, characteristics and phases of Operations Research - Types of models - Operations Research models - applications.**ALLOCATION:** Linear Programming Problem Formulation-Graphical solution- Simplex method-Artificial variable techniques: Two-phase method, Big-M method. Duality.**UNIT II:****(L-12)****TRANSPORTATION PROBLEM:** Formulation-Optimal solution, unbalanced transportation problem.**ASSIGNMENT PROBLEM:** Formulation- Optimal solution of Assignment problem- Travelling Salesman Problem.**UNIT III:****(L-12)****SEQUENCING PROBLEM:** Introduction, Flow-Shop sequencing: n jobs through two machines, n jobs through three machines. Job shop sequencing: two jobs through 'm' machines**REPLACEMENT PROBLEM:** Introduction, Replacement of items that deteriorate with time- when money value is not counted and counted. Replacement of Items that Completely Fail: Individual Replacement Policy and Group Replacement Policy.**UNIT IV:****(L-12)****GAME THEORY :** Introduction- Terminology- Solution of games with saddle points and without saddle points. 2 x 2 games- dominance principle.**INVENTORY MODELS:** Costs used in inventory models, Basic inventory models – deterministic and static demand. Models with price breaks - Models with restrictions. Single period models with probabilistic demand and without set up cost.


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UNIT V:**(L-12)**

WAITING LINES: Introduction- Basic structure of queuing models, single server and multi-server models.

PERT/CPM: Network Analysis, Program Evaluation and Review Technique (PERT), Critical Path Method (CPM).

TEXT BOOKS:

1. Hamdy A Taha: Introduction to Operations Research, 6th Edition, PHI, 1999
2. Vohra N. D.: Quantitative Techniques in Management, 3rd Edition, Tata McGraw Hill, 2007.
3. Pannerselvam R.: Operations Research, 2nd Edition, PHI, 2006.

REFERENCE BOOKS:

1. Hiller and Lieberman: Introduction to Operations Research, 7th Edition, McGraw Hill, 2001.
2. Hira and Gupta: Introduction to Operations Research, 3rd Edition, S. Chand & Company Limited, 2008.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Formulate and solve linear programming models using simplex and graphical methods and interpret duality concepts in decision-making.
2. Determine optimal transportation and assignment schedules, and apply suitable techniques to solve travelling salesman problems.
3. Construct and analyze sequencing and replacement models to optimize production schedules and equipment maintenance policies.
4. Apply game theory to determine optimal strategies and use deterministic inventory models to minimize total inventory costs.
5. Analyze queuing systems and implement PERT/CPM techniques for project evaluation, scheduling, and timely completion.

Mapping of Course Outcomes with Program Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	1	1	1	1	1	1	1	1	2	2	3	2
CO2	3	3	2	1	1	1	1	1	2	2	2	2	3	2
CO3	3	3	1	2	2	1	1	1	1	2	2	2	3	2
CO4	3	3	3	1	2	1	1	1	1	1	2	2	3	2
CO5	3	3	3	1	2	1	1	1	2	2	2	2	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially



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MACHINE TOOLS LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	0-0-3	7-5-5-R25P1	ME

Pre-Requisites: Manufacturing Processes Lab.**COURSE OBJECTIVES:** The main learning objective of this course is

1. To understand the principles of machining operations, tool geometry, and process parameters through hands-on experiments.
2. To acquire knowledge of measurement techniques for evaluating tool wear, forces, power, and machine alignment.
3. To develop skills in the use of dynamometers, measuring instruments, and testing equipment for process monitoring.
4. To analyze the performance of machine tools and manufacturing processes with respect to accuracy, safety, and efficiency.
5. To enhance practical knowledge in fabrication, testing, and evaluation of machined components.

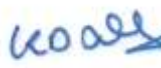
(Any eight of the following experiments will be given)

LIST OF EXPERIMENTS:

1. Differential Indexing.
2. Measurement of Tool Wear using Profile Projector.
3. Measurement of Thrust and Torque in Drilling using Drill Tool Dynamometer.
4. Measurement of Forces in Turning using Lathe Tool Dynamometer.
5. Power Measurement in Turning.
6. Preparation of Single point cutting tool using Tool and Cutter Grinder.
7. Alignment Test on Lathe Machine.
8. Alignment Test on Radial Drilling Machine.
9. Measurement of Forces in Milling using Milling Tool Dynamometer.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Apply the fundamentals of machining and manufacturing to conduct experiments on machine tools.
2. Measure and evaluate process parameters such as tool wear, forces, torque, and power using appropriate instruments.
3. Analyze experimental data to assess machine tool performance, alignment, and process accuracy.
4. Demonstrate skills in using precision measuring devices, dynamometers, and testing setups effectively.


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5. Work individually and in teams to perform experiments, interpret results, and present technical findings professionally.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	3	2	2	1	1	2	2	2	1	2	3	2
CO2	3	3	2	3	3	1	1	2	2	2	1	2	3	2
CO3	3	3	2	3	2	1	1	2	2	2	1	2	3	2
CO4	2	2	3	2	3	1	1	2	2	2	1	2	3	2
CO5	2	2	2	2	2	1	1	3	3	3	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially



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INTERNAL COMBUSTION ENGINES LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	0-0-3	7-5-5-R25P2	ME

Pre-Requisites: Fuels Lab.**COURSE OBJECTIVES:** The main learning objective of this course is

1. To provide the practical knowledge on the identification of engine parts and working principle of SI and CI engines
2. To familiarise students with various engine testing equipment and measurement systems.
3. To determine key engine performance parameters such as brake power, indicated power, brake thermal efficiency, and specific fuel consumption
4. To evaluate the influence of alternative fuels and blends on combustion and emission characteristics.
5. To train students in interpreting experimental data, plotting performance characteristics, and preparing technical reports with analytical reasoning.

List of Experiments

1. Valve timing diagram for Four-stroke Petrol (SI) Engine
2. Valve timing diagram for a four-stroke Diesel (CI) engine
3. Port timing diagram for a two-stroke petrol (SI) Engine
4. Heat balance sheet on Lister Engines.
5. Performance Test on a two-stage Air Compressor.
6. Economical Speed Test on Kirloskar Engine.
7. Load Test on Kirloskar Engine by using Bio diesel.
8. Air fuel ratio & volumetric efficiency test on Kirloskar Engine.
9. Load Test on 4- stroke Kirloskar Diesel Engine
10. Smoke and Emission Test on four stroke diesel engines with 5-Gas Analyzer.
11. Valve timing diagram for Cooper engine
12. Study and Demonstration of Assembly and Disassembly of IC Engines.


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COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. To analyse the practical knowledge on the identification of engine parts and the working principle of SI and CI engines
2. Analyse exhaust emissions (CO, CO₂, HC, NO_x) and interpret combustion efficiency and emission trends.
3. Evaluate engine performance parameters such as brake thermal efficiency, mechanical efficiency, and specific fuel consumption under different operating conditions.
4. Compare the effects of alternative fuels and blends on engine performance and emission characteristics.
5. Demonstrate teamwork, laboratory discipline, and effective communication through report preparation and presentation of experimental results.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	2	2	2	1	1	1	1	1	1	1	3	2
CO2	3	3	3	3	2	1	1	1	2	1	1	1	3	2
CO3	2	3	3	3	2	2	2	2	2	1	1	1	3	3
CO4	2	3	3	3	3	2	3	2	2	1	1	1	3	3
CO5	3	3	3	3	2	1	1	1	2	2	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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ADVANCED MANUFACTURING PROCESSES LAB**Credits: 2****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	1-0-2	7-5-5-R25S1	ME

Pre-Requisites: Manufacturing Processes Lab.**COURSE OBJECTIVES:** The main learning objective of this course is

1. To familiarize students with CNC machines, programming concepts, and simulation tools.
2. To develop skills in writing, simulating, and verifying CNC part programs for turning, milling, and drilling operations.
3. To provide hands-on experience in fabrication of components using CNC Lathe, VMC, and Wire EDM.
4. To introduce advanced manufacturing techniques such as Wire EDM and 3D printing.
5. To enhance understanding of process planning, accuracy, safety, and quality in modern manufacturing systems.

(Any Eight to Ten of the following experiments will be given)

LIST OF EXPERIMENTS:

1. Simulation of basic CNC programming for turning operations using CNC Lathe.
2. Simulation of basic CNC programming for milling operations using CNC Milling Machine.
3. Simulation and verification of manual CNC part program for drilling operation.
4. Simulation and verification of CNC part program for complete component machining using CNC Lathe.
5. Simulation and verification of CNC part program for component machining using Vertical Machining Centre (VMC).
6. Fabrication of a component-1 using CNC Lathe.
7. Fabrication of a component-2 using CNC Lathe.
8. Fabrication of a component-1 using Vertical Machining Centre (VMC).
9. Fabrication of a component-2 using Vertical Machining Centre (VMC).
10. Production of part- 1 using wire EDM.
11. Production of part- 2 using wire EDM.
12. Design and Fabrication of a component-1 using 3D printing.
13. Design and Fabrication of a component-2 using 3D printing.


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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Prepare detailed part designs and component drawings suitable for advanced manufacturing operations.
2. Simulate, and verify CNC programs for turning, milling, drilling, machining operations, and 3D printing processes.
3. Fabricate components accurately using CNC Lathe, VMC, Wire EDM, and 3D printing based on design specifications.
4. Work individually or in teams to interpret experimental results, analyze deviations, and present technical findings professionally.
5. Demonstrate safe working practices, ensure dimensional accuracy, and maintain quality control during all CNC and advanced manufacturing operations.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	3	—	2	—	—	—	—	—	—	1	3	2
CO2	3	3	2	2	3	—	—	—	1	—	—	1	3	2
CO3	3	3	3	2	3	—	—	—	1	—	2	1	3	2
CO4	2	2	2	3	2	—	1	—	3	3	1	2	3	2
CO5	2	2	2	2	2	1	2	1	2	2	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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ANCIENT INDIAN METALLURGY & MATERIAL SCIENCE**(IKS Mandatory)****Credits: 0****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
IV	2-0-0	7-5-5-R25MK	ME

Course Description:**COURSE OBJECTIVES:** The main learning objective of this course is

1. Provide knowledge of the origin and evolution of metallurgical practices in ancient India.
2. Explain iron, steel, and non-ferrous metal production techniques used in ancient times.
3. Introduce advanced traditional metallurgical and casting methods and their scientific relevance.
4. Familiarize students with Rasashastra and alchemical traditions and their influence on metallurgy and material science.
5. Enable students to analyze archaeological and textual evidence to understand the legacy and sustainability of ancient Indian metallurgical knowledge.

Unit-I**(L-12)****Introduction to Early Metal Usage**

This unit introduces early metallurgical practices in ancient India, covering the Chalcolithic Copper Age, copper and bronze tools, mining and refining techniques of the Aravalli region, Harappan metallurgical methods, and the development of alloys such as bronze and arsenic-lead alloys

Unit-II**(L-12)****Iron and Steel Production**

This unit focuses on the Iron Age in India, early iron smelting and blacksmithing techniques, the development of Wootz crucible steel in South India, and a case study of the Delhi Iron Pillar highlighting its corrosion-resistant composition.

Unit-III**(L-12)****Advanced Metallurgical Techniques**

This unit deals with non-ferrous metal processing, including ancient zinc smelting and distillation methods, production of brass, bronze, bell metal, and precious metals, and traditional casting techniques such as the lost-wax method.


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Unit-IV

(L-12)

Alchemy and Rasashastra

This unit covers the principles of Rasashastra, contributions of Acharya Nagarjuna, purification and transformation of metals, use of mercury and minerals, and the link between alchemy, metallurgy, and medicine.

Unit-V

(L-12)

Archaeological and Textual Evidence

This unit examines textual references to metallurgy in the *Arthashastra* and *Rasaratna Samuccaya*, archaeological evidence from Harappa, Mohenjodaro, and Zawar, and the legacy of ancient Indian metallurgical knowledge.

Text Books:

1. **Ancient Indian Mining, Metallurgy and Metal Industries (Vols. 1 & 2)** – Motilal Banarsidass. Comprehensive study of metallurgy in ancient India: copper, iron, steel, zinc, brass, gold, and silver.
2. **Ancient Metal Technology and Archaeology of South Asia** – B. Agrawal (Aryan Books International) Archaeometallurgical techniques, ore sources, and early metalworking in the subcontinent.
3. **Metallurgy in Indian Archaeology** – H.C. Bhardwaj Covers metal extraction, alloy formation, and archaeological evidence from Harappan to Gupta periods.
4. **Mining and Metallurgy in Ancient India** – Rina Shrivastava Historical metallurgy with primary evidence from mining sites, ores, and processing methods.
5. **Rasaratna Samuccaya** (Medieval Sanskrit Text) – Translations / Commentaries Classic treatise combining alchemy and metallurgy, describing laboratory techniques and metal purification. The text is also discussed in academic journals.

Reference Books:

1. **Metals and Metallurgy in Ancient India** – Sharada Srinivasan & Srinivasa Ranganathan *Scholarly examination of iron, steel, bronze, brass, and archaeological metallurgical discoveries.*
2. **Early Indian Metallurgy** (various papers in Indian Journal of History of Science)
Articles on iron smelting, Wootz steel, brass, zinc, and alloy technology — e.g., B. Prakash (Iron & Steel); Arun K. Biswas (Brass & Zinc).


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3. **Historical Context & Civilizational Background** *Debiprasad Chattopadhyaya — Lokayata: A Study in Ancient Indian Materialism* (philosophical context of material culture).

Introductory Material Science / Metallurgy Texts (for foundational theory)

Callister & Rethwisch – Materials Science and Engineering (basic alloy & process concepts)

COURSE OUTCOMES: After successful completion of this course, the students will be able to

1. CO1: Describe early metal usage, mining, and alloy development during the Chalcolithic and Harappan periods.
2. CO2: Explain ancient Indian iron and steel production techniques, including Wootz steel and corrosion-resistant iron.
3. CO3: Analyze traditional non-ferrous metal processing and casting techniques using material science principles.
4. CO4: Interpret the principles of Rasashastra and assess its role in metallurgy, alchemy, and medicine.
5. CO5: Evaluate archaeological and textual evidence to appreciate the technological and sustainable aspects of ancient Indian metallurgy.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO3	2	3	2	2	1	1	1	1	1	1	1	3	3	3
CO4	2	2	3	2	1	1	1	1	1	1	1	3	3	3
CO5	1	2	3	3	2	1	2	1	1	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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NON - CONVENTIONAL ENERGY SOURCES
(PROFESSIONAL ELECTIVE -I-1)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E11	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1.	Introduce the fundamental concepts of solar radiation and its potential as a renewable energy source.
2.	Study various solar energy collection and utilization systems, including photovoltaic and thermal technologies.
3.	Understand the principles, technologies, and applications of wind energy and bio-energy systems.
4.	Explore other renewable energy sources like geothermal, ocean thermal, tidal, and wave energy, including their working principles and potential.
5.	Analyze advanced direct energy conversion technologies such as fuel cells, thermoelectric, and magnetohydrodynamic (MHD) systems.

COURSE CONTENT:**UNIT I:**

Introduction: Role and potential of new and renewable sources – The solar energy option – Environmental impact of solar power.

Principles of Solar Radiation: Physics of the sun – The solar constant – Extraterrestrial and Terrestrial solar radiation – Solar radiation on tilted surface – Instruments for measuring solar radiation and sun shine – Solar radiation data.

UNIT II:

Solar Energy Collection: Flat plate and concentrating collectors – Classification of concentrating collectors – Orientation and Thermal analysis – Advanced collectors.

Solar thermal systems: Principle of working of solar water heating systems, solar cookers, solar desalination systems, solar ponds, solar chimney power plant.

Solar Applications: Solar heating/cooling techniques – Solar distillation and drying - Photovoltaic energy conversion


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UNIT III:

Wind Energy: Sources and potentials – Horizontal and Vertical axis windmills – Performance characteristics.

Bio-Mass: Principles of Bio-conversion – Anaerobic/Aerobic digestion – Types of Bio-gas digesters – Gas yield – Combustion characteristics of bio-gas – Utilization for cooking, I.C. engine operation – Economic aspects.

UNIT IV:

Geothermal Energy: Resources – Types of wells – Methods of harnessing the energy – Potential in India.

OTEC: Principles – Utilization – Setting of OTEC plants - Thermodynamic cycles.

Tidal and Wave Energy: Potential and Conversion techniques – Mini-hydel power plants – Their economics.

UNIT V:

Direct Energy Conversion: Need for DEC – Carnot cycle – Limitations – Principles of DEC – Thermo-electric generators – Sebeck, Peltier and Joule Thompson effects – Figure of merit – Materials – Applications.

MHD generators: – Principles – Dissociation and Ionization – Hall effect – Magnetic flux – MHD accelerator – MHD engine – Power generation systems – Electron gas dynamic conversion – Economic aspects

Fuel Cells: Principle – Faraday's laws – Thermodynamic aspects – Selection of fuels and Operating conditions.

TEXT BOOKS:

1. P.L. Bellany, Thermal Engineering, Khanna Publishes.
2. Benjamin J., Basic Mechanical Engineering, Pentex.
3. Rai G.D. : Non-conventional Energy Sources, Standard Publishers Distributors.

REFERENCE BOOKS:

1. R.C.Patel, Elements of heat engines, Acharya Publishers.
2. G.R Nagapal, Power plant engineering, Khanna publishes.
3. P.K.Nag, Engineering Thermodynamics, McGraw Hill.
4. Dr.P.R Modi & Dr.M.S. Seth, Hydraulics & Fluid Mechanics including Hydraulic Machines, Standard Book House.


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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Evaluate the role of solar energy in the current and future global energy scenario, and explain the principles of solar radiation and its environmental impacts compared to conventional energy sources.
2. Analyze the design and performance of various solar energy collection systems and evaluate their suitability for different thermal and electrical applications.
3. Compare the operational principles of wind turbines and bio-energy systems, and assess their performance and economic feasibility.
4. Describe the working principles of geothermal, OTEC, tidal, and wave energy systems, and evaluate their potential and implementation challenges.
5. Examine the mechanisms of direct energy conversion technologies, including fuel cells and MHD generators, and their application in modern power systems.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	2	1	1	1	2	3	1	1	1	1	2	2	2
CO 2	3	2	2	2	2	1	3	1	1	2	1	1	2	2
CO 3	3	2	2	2	1	1	3	1	1	2	2	2	2	2
CO 4	3	2	2	2	1	1	3	1	2	2	2	1	2	2
CO 5	3	2	2	2	2	1	2	1	1	2	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially



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WELDING TECHNOLOGY
(PROFESSIONAL ELECTIVE -I-2)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E12	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is	
1.	Understand the different types of welding Arc welding processes and power sources.
2.	Analyze the parameters that influences Arc welding processes and variables of Arc welding.
3.	To visualize the Resistance welding & Energy welding processes.
4.	To explore the different types of solid state joining processes & its allied processes.
5.	To identify appropriate remedies and preventive measures for minimizing welding defects.

COURSE CONTENT:**UNIT I:****(L-12)**

Basics of arc welding processes - Classification of welding and allied Processes - Welding arc: physics involved in arc, structure and characteristics, arc efficiency calculation, methods of arc initiation and maintenance, arc stability, arc blow - V-I characteristics, constant current and constant voltage characteristics, duty cycle.

Arc Welding Power Sources: welding transformers, generators, rectifiers, inverters; Classification of electrodes and their applications, Metal Transfer: forces affecting metal transfer - modes of metal transfer. Conventional gas welding and cutting,

UNIT II:**(L-8)**

Arc welding processes-Basic principles, Process variables, Chief characteristics and applications of the following processes: Shielded (Manual) Metal Arc Welding (SMAW/MMAW) - Submerged Arc Welding (SAW), Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), CO₂ welding, Electro Slag and Electro Gas Welding.

UNIT III:**(L-8)**

Resistance welding processes Basic principle, Process variables, Welding Sequence, Process characteristics and applications of the following processes: Spot welding, simple problems - Seam welding - Projection welding - Resistance Butt welding - Flash Butt welding.



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Plasma arc welding process- Transferred and Non- Transferred arc welding and their applications-Plasma cutting- surfacing and applications. Radiant energy welding processes - equipment -Electron Beam Welding (EBW) - Laser Beam Welding (LBW) - applications of EBW and LBW- Friction Stir Welding (FSW).

UNIT IV: (L-8)

Explosive & Diffusion and Ultrasonic Welding: principles of operation- process characteristics and applications.

Soldering: Techniques of soldering- solders- phase diagram- composition- applications

Brazing: Wetting and spreading characteristics- surface tension and contact angle- concepts- brazing fillers- adhesive bonding- Cladding- Surfacing and Cutting

UNIT V: (L-8)

Welding Defects: Defects in welded joints: Defects such as arc strike- porosity- undercut- slag entrapment and hot cracking- causes and remedies in each case. Joining of dissimilar materials-Weldability tests- effect of metallurgical parameters.

TEXT BOOKS:

1. Parmar, R.S., "Welding Engineering and Technology", Khanna Publishers, Third Edition, New Delhi, 2013.
2. Welding and Welding Technology-Little (LR)- Tata McGraw Hill- New Delhi-
3. Khanna, O.P., "Welding Technology" Dhanpat Rai & Sons Publishers, New Delhi, 2024.

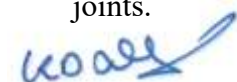
REFERENCE BOOKS:

1. Welding Technology and Design, V M Radha Krishnan & M Kamaraj, New age Publisher, Pvt. Ltd, Third Edition 2019.
2. Advanced Welding Systems. Vol.1; Vol.2 and 3 by Jean Cornu, USA Edition.
3. Modern Welding, 13th Edition, William A. Bowditch & Mark A. Bowditch. 2024

COURSE OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. Classify and distinguish the fundamental principles and applications of various welding and allied processes
2. Explain the basic principles and differentiate the underlying mechanisms.
3. To describe the operating mechanisms and key applications of welding processes.
4. Able to explain the principles of solid-state joining processes and analyse techniques of soldering & brazing.
5. Ability to classify and explain the occurrence of major welding defects in welded joints.



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Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	2	1	1	2	1	1	-	-	1	1	2	2	2
CO2	3	3	2	2	2	-	-	1	-	-	2	2	1	2
CO3	3	2	3	2	3	1	1	1	1	1	1	2	2	1
CO4	3	3	2	3	2	-	-	-	-	-	2	2	2	2
CO5	3	2	2	3	2	1	1	1	-	1	1	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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MECHANICAL VIBRATIONS

(PROFESSIONAL ELECTIVE -I-3)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E13	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Understand basic concepts of vibration, its causes, effects, and classification of vibrating systems.
2. Formulate mathematical models for vibrating systems using physical laws and assumptions.
3. Analyze free and forced vibrations of single and two degree of freedom systems.
4. Study vibration behavior of multi-degree and continuous systems using analytical methods.
5. Apply vibration analysis techniques for practical engineering systems and design vibration control devices.

COURSE CONTENT:**UNIT I: (L-10)**

Introduction: Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

UNIT II: (L-10)

Single Degree of Freedom (SDF) systems: Formulation of equation of motion: Newton – Euler method, De Alembert's method, Energy method, Free Vibration: Undamped Free vibration response, Damped Free vibration response, Case studies on formulation and response calculation. Forced vibration response of SDF systems: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances.

UNIT III: (L-10)

Two degree of freedom systems: Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion, Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, coupled pendulum, free vibration response case studies, Forced vibration response, Automobile as a two degree of freedom system

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bouncing and pitching modes undamped vibration absorbers, Case studies on identification of system parameters and design of undamped vibration absorbers. Analysis and design of damped vibration absorbers.

UNIT IV:**(L-10)**

Multi degree of freedom systems: Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonality of modal vectors, normalization of modal vectors, Decoupling of modes, modal analysis, mode superposition technique, Free vibration response through modal analysis, Forced vibration analysis through modal analysis, Modal damping, Rayleigh's damping, Introduction to experimental modal analysis.

UNIT V:**(L-10)**

Continuous systems: Introduction to continuous systems, discrete vs continuous systems, Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems Case studies, Approximate methods for continuous systems and introduction to Finite element method.

TEXT BOOKS:

1. L. Meirovich, Elements of Vibration Analysis, Tata Mc-Grawhill, 2007, 2nd Edition.
2. Singiresu S Rao, Mechanical Vibrations, Pearson education, 2011, 4th Edition.

REFERENCE BOOKS:

1. W.T. Thomson and M.D. Dahleh, Theory of vibration with applications, Pearson Education, Inc, 2007.
2. Max Irvine, Structural dynamics, Allen and Unwin, 1980
3. Venkatachalam R., Mechanical Vibrations, PHI Publications, 2018.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Identify different types of vibrating systems and develop physical, schematic, and mathematical models.
2. Formulate equations of motion and determine free and forced vibration responses of single degree of freedom systems.
3. Analyze two degree of freedom systems to determine natural frequencies, mode shapes, and vibration responses.
4. Apply modal analysis techniques to study free and forced vibrations of multi degree of freedom systems.
5. Analyze vibration behavior of continuous systems and apply approximate methods including basic finite element concepts.


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Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	1	–	–	–	–	–	–	–	–	1	2	1
CO2	3	3	2	1	1	–	–	–	–	–	–	–	2	1
CO3	3	3	2	2	1	–	–	–	–	–	–	–	2	1
CO4	3	3	2	3	2	–	–	–	–	–	–	1	2	1
CO5	3	3	2	2	3	–	–	–	–	–	–	1	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PRODUCT DESIGN AND DEVELOPMENT**(PROFESSIONAL ELECTIVE -I-4)****Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E14	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Understand and apply design thinking philosophy and structured product design processes in engineering contexts.
2. Identify and analyze customer needs using systematic tools to translate them into engineering requirements.
3. Gather, interpret, and utilize information including patents, codes, standards, and intellectual property for product design.
4. Generate, evaluate, and select design concepts using creative methods and rational decision-making techniques.
5. Develop embodiment and detailed designs considering technical, ethical, legal, and manufacturability aspects through team-based projects.

COURSE CONTENT:**UNIT I:****(L-10)**

Introduction: Design thinking philosophy - Empathy, Define, Ideate, Prototype, Test. Product design context- types of designs, Asimov model, Design method vs scientific method, Considerations of a good design, Design activities/ Process, Product life and technological insertion cycles, organisational structures, business models, Design in teams-Team behaviour and dynamics. Team formation and Course project assignment.

UNIT II:**(L-10)**

Problem identification: Need analysis, customer study and need identification tools, Product Quality and classification of Customer requirements, Kano Diagram. Establishing Engineering characteristics- Benchmarking, Quality Function Deployment- HOQ, Preparation of Initial PDS for the Course Project.

UNIT III:**(L-10)**

Gathering Information: Transformation from Data to knowledge, types and sources of information, intellectual property rights- classification, Patent searching, stages of patent filing. Importance of Codes and standards in Product Design.



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UNIT IV:**(L-10)**

Concept Generation/Improvement and Decision making: Creative thinking models, creative thinking aids and barriers, structured and unstructured creative design methods/theories- Brainstorming techniques, Random input technique and Synectics, concept map, Functional decomposition, Morphological analysis, TRIZ, Axiomatic Design, practice exercises. Decision making theories- criteria based selection, Pugh's concept, AHP.

UNIT V:**(L-10)**

Embodiment and Detailed Design: Product Architecture, Configuration and Parametric design Concepts, Detailed design, Engineering Requirements - failure mode and effects analyses, Legal and ethical issues in design. DFX, Course Project Reviews.

TEXT BOOKS:

1. George E Dieter, Engineering Design, Publisher, McGraw Hill, 4th edition.

REFERENCE BOOKS:

1. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.
2. W. Ernest Eder, S. Hosendtl., "Design Engineering", CRC Press, 2008.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Apply design thinking stages and product design methodologies to solve open-ended engineering problems.
2. Analyze customer needs and convert them into structured engineering specifications using tools like Kano model and QFD.
3. Collect and evaluate technical information, patents, codes, and standards relevant to product development.
4. Generate innovative design concepts and select optimal solutions using creative techniques and multi-criteria decision-making tools.
5. Develop embodiment and detailed product designs incorporating reliability, DFX principles, and ethical and legal considerations in a team environment.

Mapping of Course Outcomes with Program Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	2	2	3	—	1	—	—	—	2	1	—	1	2	1
CO2	2	3	3	1	2	—	—	—	1	1	1	—	2	1
CO3	2	2	1	3	2	1	—	1	—	—	—	2	2	1
CO4	2	3	3	1	2	—	—	—	1	1	1	—	2	1
CO5	2	2	3	1	2	2	1	3	3	2	2	1	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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BIOMEDICAL ENGINEERING
(PROFESSIONAL ELECTIVE -I-5)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E15	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is to

1. Understand the evolution and scope of biomedical engineering and its role in modern healthcare systems.
2. Apply principles of anatomy, physiology, and biomechanics to analyze biological systems and human movement.
3. Explain the selection, properties, and interactions of biomaterials used in medical and tissue engineering applications.
4. Analyze bioinstrumentation systems, sensors, and transport processes relevant to diagnosis and therapy.
5. Understand the working principles of medical imaging systems used for clinical diagnosis and research.

COURSE CONTENT:**UNIT I:****(L-12)****BIOMEDICAL ENGINEERING: A HISTORICAL PERSPECTIVE:**

The Evolution of the Modern Health Care System, The Modern Health Care System, What Is Biomedical Engineering, Recent Advances in Biomedical Engineering.

ANATOMY AND PHYSIOLOGY OVERVIEW FOR ENGINEERS:

Introduction, Cellular Organization, Tissues, Major Organ Systems, Homeostasis.

UNIT II:**(L-12)****BIOMECHANICS:**

Introduction, Basic Mechanics, Mechanics of Materials, Viscoelastic Properties, Cartilage, Ligament, Tendon, and Muscle, Clinical Gait Analysis, Cardiovascular Dynamics.

BIOMATERIALS:

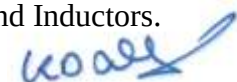
Materials in Medicine: From Prosthetics to Regeneration, Biomaterials: Types, Properties, and Their Applications, Lessons from Nature on Biomaterial Design and Selection. Tissue–Biomaterial Interactions, Biomaterials Processing Techniques for Guiding Tissue Repair and Regeneration.

UNIT III:**(L-12)****TISSUE ENGINEERING:**

What Is Tissue Engineering, Biological Considerations, Physical Considerations, Implementation of Tissue Engineered Products.

BIOINSTRUMENTATION:

Basic Bioinstrumentation System, Current, Voltage, Power, and Energy. Resistance, Linear Network Analysis. Linearity and Superposition, Thevenin's Theorem, Inductors, Capacitors, A General Approach to Solving Circuits Involving Resistors, Capacitors, and Inductors.



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UNIT IV:**(L-12)****BIOMEDICAL SENSORS:**

Biopotential Measurements, Physical Measurements, Blood Gas Sensors, Bioanalytical Sensors, Optical Sensors. **BIOMEDICAL TRANSPORT PROCESSES:**

Biomedical Mass Transport, Biomedical Heat Transport.

UNIT V:**(L-10)****MEDICAL IMAGING SYSTEMS:**

Radiation Imaging: Basic Concepts of Emission Imaging Systems, Instrumentation and Imaging Devices, Radiographic Imaging Systems. Fundamentals of Diagnostic Ultrasound Imaging, Magnetic Resonance Imaging, Magnetoencephalography.

TEXT BOOKS:

1. Introduction to Biomedical Engineering, John D. Enderle and Joseph D. Bronzino, Third Edition, Academic Press, 2012.

REFERENCE BOOKS:

1. Fundamentals of Biomedical Engineering Technology, G.S. Sawhney, New age International (P) Limited, Publishers.
2. Biomechanics: Mechanical Properties of Living Tissues, Robert M. Nerem, Springer, 1991.
3. Biomaterials: An Introduction, Joon B. Park and Roderic S. Lakes, Third Edition, Springer, 2007.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand the role and development of biomedical engineering and basic human anatomy and physiology.
2. Apply biomechanics and biomaterials concepts to analyze biological tissues and medical applications.
3. Understand the fundamentals of tissue engineering and basic bioinstrumentation circuits.
4. Explain the working principles of biomedical sensors and transport processes in biological systems.
5. Understand the principles and applications of major medical imaging systems.

Mapping of Course Outcomes with Program Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	1	1	1	1	2	1	–	–	1	–	2	1	1
CO2	3	3	2	1	1	1	1	–	–	1	–	2	1	1
CO3	3	2	2	1	1	1	1	–	–	1	–	2	1	1
CO4	3	2	2	2	1	1	1	–	–	1	–	2	1	1
CO5	3	2	2	1	2	1	1	–	–	1	–	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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GEOMETRIC MODELLING FOR CAD

(PROFESSIONAL ELECTIVE -I-6)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E16	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is to

1. Understand the fundamentals of geometric modelling and coordinate transformations.
2. Apply mathematical methods to represent curves and surfaces used in CAD systems.
3. Develop and implement algorithms for generating and manipulating geometric entities.
4. Analyze and evaluate geometric modeling techniques for design applications.
5. Utilize CAD tools to model complex shapes and perform surface modeling

COURSE CONTENT:**UNIT I:****(L-12)****Introduction to Geometric Modeling**

This unit introduces the importance and applications of geometric modeling in CAD. It covers types of geometric models such as wireframe, surface and solid models. Coordinate systems, homogeneous coordinates, and geometric transformations including translation, rotation and scaling are discussed with relevance to CAD environments.

UNIT II:**(L-12)****Curve Modeling**

This unit focuses on mathematical representation of curves used in CAD systems. Topics include parametric curves, polynomial curves, Bezier curves and B-spline curves. Properties such as continuity, convex hull and curve evaluation techniques are also explained along with basic curve generation algorithms.

UNIT III:**(L-12)****Surface Modeling**

This unit deals with the generation and representation of surfaces. It includes parametric surfaces, Bezier surfaces, B-spline and NURBS surfaces. Surface properties, surface blending, trimming and evaluation techniques are introduced with applications in product design



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UNIT IV: Solid Modeling**(L-12)**

This unit covers solid modeling concepts and data structures. Boundary Representation (B-Rep) and Constructive Solid Geometry (CSG) techniques are explained. Boolean operations on solids and their role in creating complex 3D models are discussed

UNIT V:**(L-10)****Geometric Modeling Algorithms and CAD Implementation**

This unit introduces algorithmic aspects of geometric modeling. Topics include intersection and offset algorithms, basic mesh generation concepts, and practical implementation of geometric models using CAD software tools. Case studies related to engineering design applications are included.

TEXT BOOKS:

1. Michael E. Mortenson, *Geometric Modeling*, Industrial Press.
2. Donald Hearn and M. Pauline Baker, *Computer Graphics*, Pearson.
3. Ibrahim Zeid, *CAD/CAM: Theory and Practice*, McGraw-Hill.

REFERENCE BOOKS:

1. Gerald Farin, *Curves and Surfaces for Computer Aided Geometric Design*, Morgan Kaufmann.
2. Les Piegl and Wayne Tiller, *The NURBS Book*, Springer
3. Farid Karim, *Principles of Computer Aided Design and Manufacturing*, PHI.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1.	Explain the fundamental concepts of geometric modeling, coordinate systems and geometric transformations used in CAD systems.
2.	Apply mathematical techniques to represent and generate parametric curves such as Bezier, B-spline and NURBS curves.
3.	Develop and analyze surface models including Bezier, B-spline and NURBS surfaces for engineering design applications.
4.	Analyze solid modeling techniques such as Boundary Representation (B-Rep) and Constructive Solid Geometry (CSG) for creating complex 3D models.
5.	Use modern CAD tools and geometric modeling algorithms to create, evaluate and modify geometric models for practical engineering applications.

Mapping of Course Outcomes with Program Outcomes:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2
CO1	3	1	1	2	1	1	1	1	2	1
CO2	3	2	1	3	1	1	1	1	3	2
CO3	3	2	1	3	1	1	1	1	3	3
CO4	2	3	2	2	1	1	1	1	3	1
CO5	2	2	3	3	1	1	1	2	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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ADVANCED MANUFACTURING PROCESSES (PROFESSIONAL ELECTIVE -II-1)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E21	ME

Pre-Requisites: Material Science and Engineering, Manufacturing Processes.

COURSE OBJECTIVES: The primary learning objective of this course is to prepare the students to understand and learn

1. About advanced mechanical processes like ultrasonic, water jet, and abrasive jet machining methods.
2. Explore the chemical and electrochemical machining methods.
3. About the combination of different energies involved in material removal techniques known as hybrid machining processes.
4. Thermal processes like EDM, Wire-EDM, LBM, PBM, EBM, and IBM.
5. Different material addition processes and their importance in improving efficiency, productivity, quality, and sustainability in the manufacturing industry.

COURSE CONTENT: *Material Removal Processes- Introduction, history of machining, traditional machining processes, non-traditional machining processes, hybrid machining processes. Need for non-traditional machining processes.*

UNIT I:

MECHANICAL PROCESSES:

Ultrasonic Machining - Introduction, Machining System, Material Removal Process, Factors Affecting Material Removal Rate, Dimensional Accuracy and Surface Quality, Applications.

Water jet machining - Introduction, The machining system, Process parameters, Applications, Advantages, and Disadvantages

Abrasive jet machining - Introduction, Machining system, Material removal rate, Applications, Advantages, and limitations of AJM.

UNIT II:

CHEMICAL PROCESSES:

Chemical Milling - Introduction, Tooling for CHM, Process parameters, Material removal rate, Accuracy and surface finish, Advantages, Limitations, Applications

Photochemical Milling - Introduction, Process description Applications, Advantages

Electro Polishing - Introduction, Process parameters, Applications, Process limitations.

ELECTROCHEMICAL PROCESSES:

Electrochemical Machining: Introduction, Principles of electrolysis, Theory of ECM, ECM equipment, Basic working principles, Process characteristics, Process control, Applications, Basics of Electrochemical Drilling, Electrochemical Deburring, and Electro stream Drilling

UNIT III:

HYBRID ELECTROCHEMICAL PROCESSES: Electrochemical Grinding - Introduction, Material removal rate, Accuracy and surface quality, Applications, Advantages and disadvantages

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UNIT IV:**THERMAL PROCESSES:**

Electro Discharge Machining-Introduction, Mechanism of material removal, The machining system, Material removal rates, Heat-affected zone, Applications. Wire EDM principle, Process parameters, surface finish and machining accuracy, applications.

Laser beam machining - Introduction, material removal mechanism, applications, advantages, and limitations.

Electron Beam Machining - Introduction, Basic Equipment, Removal Mechanism, Applications, Advantages, and Disadvantages.

Plasma beam machining - Introduction, Machining Systems, Material Removal Rate, Accuracy and Surface Quality, Applications, Advantages and Disadvantages.

Ion beam machining - Introduction, Material Removal Rate, Accuracy and Surface Effects, Applications

UNIT V:

MATERIAL ADDITION PROCESSES: Introduction, Classification

Liquid-Based Techniques: Stereo-Lithography, Holographic Interference Solidification, Beam Interference Solidification, Solid Ground Curing, Liquid Thermal Polymerization, Fused Deposition, Modeling, Multi-Jet Modeling, Ballistic Particles Manufacturing, Shape Deposition Manufacturing. **Powder-based processes:** Selective Laser Sintering, Laser Engineered Net Shaping, Three-Dimensional Printing.

Solid-based techniques: Solid Foil Polymerization, Laminated Object Modeling.

TEXT BOOKS:

1. El-Hofy, Hassan Abdel-Gawad, "Advanced Machining Processes: Non-traditional And Hybrid Machining Processes", McGraw-Hill, 2005.

REFERENCE BOOKS:

1. Pandey P.C. and Shah H.S., "Modern Machining Processes", 1st Edition, TMH, 2010.
2. Bhattacharya A, "New Technology, the Institution of Engineers", India 1984.
3. V. K. Jain, "Advanced machining processes", 1st Edition, Allied Publishers, 2010



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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Analyze the different elements and characteristics of Water Jet Machining, Abrasive Jet Machining, and Ultrasonic Machining, and their applications.
2. Identify and describe the process parameters, equipment, and tooling used in Chemical Milling, Photochemical Milling, and Electro Polishing techniques.
3. Evaluate the advantages, limitations, and practical applications of Electrochemical Grinding, Honing, Super Finishing, and Buffing processes.
4. Analyze the influence of process parameters on material removal rate, machining accuracy, and surface finish in different thermal processes.
5. Explain the fundamentals and classifications of various material addition (additive manufacturing) processes.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	-	-	2	3	3
CO2	3	2	2	2	2	-	-	-	-	-	-	2	2	2
CO3	3	3	2	2	2	1	2	-	-	-	1	2	3	2
CO4	3	3	2	3	3	1	2	-	-	-	1	2	2	1
CO5	3	2	3	2	3	-	3	1	-	-	1	3	3	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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COMPOSITE MATERIALS

(PROFESSIONAL ELECTIVE -II-2)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E22	ME

Pre-Requisites: To successfully learn and understand the concepts of Composite Materials students are expected to have prior knowledge of Engineering materials and Manufacturing process.

COURSE OBJECTIVES: The main learning objective of this course is

1. Understand the fundamental concepts, classifications, and advantages of composite materials over conventional materials.
2. Explain various manufacturing techniques used in the production of composite materials through open and closed moulding processes.
3. Identify and evaluate different reinforcement materials (fibers and particles), their properties, and their impact on composite performance.
4. Comprehend the structure, fabrication methods, and applications of polymer matrix and metal matrix composites.
5. Analyze the micromechanical behaviour of composites, including prediction of elastic constants and stress distribution using micromechanical models such as Halpin-Tsai equations.

Course Content:

Significance and Manufacturing methods of Composites.

UNIT I:

Basics of Composites

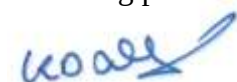
Introduction: Definition, Classification of Composite materials based on structure, based on matrix, Advantages of composites, Applications of composites, Functional requirements of reinforced and matrix.

Types of Composites: Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC).

UNIT II:

Manufacturing Methods

Overview of Composite fabrication techniques: Open moulding methods Hand – lay up process, Spray – lay up process, Filament winding process Closed moulding methods: Compressive moulding, Vacuum bag moulding, Pultrusion process and Resin Transfer Moulding process.



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UNIT III:**Reinforcement Material**

Types of reinforcements and their properties: Fibers: Carbon, Boron, Glass, Aramid, Al_2O_3 , SiC, Nature and Manufacture of glass, Carbon and Aramid fibers, Comparison of fibers.

UNIT IV:**Polymer and Metal Matrix Composites**

Fabrication of Polymeric Matrix Composites: Structure and Properties of Polymeric Matrix Composites Interface in Polymeric Matrix Composites, Applications.

Fabrication of Metal Matrix Composites: Solid state fabrication, Liquid state fabrication and In – situ fabrication techniques.

UNIT-V**MICROMECHANICS OF COMPOSITES**

Basic concepts of micromechanics, Volume and weight fractions, Density and elastic constants, Longitudinal and transverse modulus, Rule of mixtures, Stress-strain relations, Halpin-Tsai equations, Prediction of mechanical behaviour, Simple problems on stiffness and strength estimation.

TEXT BOOKS:

1. K.K. Chawla, Composite Materials - Science and Engineering, Springer, 3rd Edition.
2. An introduction to Composite Materials, Hull, Cambridge, 2nd Edition, 1997
3. P.K. Mallick, Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press, 3rd Edition.
4. A textbook of Manufacturing Technology: Manufacturing Processes by R.K. Rajput, 2nd Edition

REFERENCE BOOKS:

1. B.D. Agarwal, L.J. Broutman, and K. Chandra Shekhara, Analysis and Performance of Fiber Composites, Wiley India
2. Mathews, F.L. and Rawlings, R.D., Composite Materials: Engineering and Science, Woodhead Publishing.
3. Autar K. Kaw, Mechanics of Composite Materials, CRC Press.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to

1. Able to understand the fundamentals of composite materials, their classification, advantages, and applications.
2. Able to understand and describe various open and closed moulding manufacturing methods of composite materials.
3. Identify different types of reinforcing fibers and understand their properties and role in composites.
4. Understand the fabrication techniques, structure, and properties of polymer matrix and metal matrix composites.
5. Apply micromechanical concepts to determine density, elastic constants, and mechanical properties of composites.

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COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	1	1	1	1	1	1	2	1	3	3	2
CO2	3	2	2	1	2	1	1	1	1	1	1	3	3	2
CO3	3	3	2	2	2	1	1	1	1	1	1	2	3	3
CO4	3	3	3	2	2	1	1	1	1	2	1	3	3	3
CO5	3	3	3	3	2	1	1	1	1	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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TIRUPATI-517 502

DESIGN FOR MANUFACTURING AND ASSEMBLY

(PROFESSIONAL ELECTIVE -II-3)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E23	ME

Pre-Requisites: Manufacturing processes

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to learn

1. Design for creativity, manufacturability, economy, evaluation.
2. Understand and apply material, process, and design principles for forging, extrusion, and sheet metal components
3. Understand design features that enhance machining efficiency and simplicity.
4. Understand casting processes, select appropriate methods, and apply design principles effectively.
5. Understand eco-friendly design principles emphasizing sustainability and environmental responsibility.

COURSE CONTENT:

The course focuses on design philosophy, processes, and manufacturability principles emphasizing creativity, economy, and mechanical factors.

UNIT I:**Introduction:**

Design Philosophy-Steps In Design Process-General Design Rules For Manufacturability-Basic Principles Of Designing For Economical Production-Creativity In Design, General Design Rules For Machining And Manufacturability: Strength And Mechanical Factors, Mechanisms. Selection, Evaluation Method.

UNIT II:**Factors Influencing form Design:**

Working Principle, Material, Manufacture, Design- Possible Solutions, Materials Choice, Influence of Materials on Form Design, Form Design Of Forging, Extrusion & Sheet Metal Work

Forging: Design Factors For Forging – Closed Die Forging Design – Parting Lines of Dies – Drop Forging Die Design – General Design Recommendations.

Extrusion & Sheet Metal Work: Design Guidelines Extruded Sections-Design Principles For Punching, Blanking, Bending, Deep Drawing-Keeler Goodman Forging Line Diagram – Component Design For Blanking.


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UNIT III:

Machining Consideration: Design Features to Facilitate Machining: Drills, Milling Cutters,

Keyways, Doweling Procedures, Counter Sunk Screws, Reduction of Machined Area, Simplification

By Separation, Simplification By Amalgamation

UNIT IV:

Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting-casting tolerance-use of solidification-product design rules for sand casting.

UNIT V:**Design for the Environment:**

Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines, Example application, Lifecycle assessment, Basic method, Environment responsible product assessment, Weighted sum assessment and Lifecycle assessment methods, Design to minimize material usage, Design for disassembly, Design for recyclability, Design for remanufacture, Design for energy efficiency, Design to regulations and standards

TEXT BOOKS:

1. Kevien Otto and Kristin Wood, Product Design. Pearson Publication, 2004.
2. Product design and development, by K.T. Ulrich and S.D. Eppinger, Tata McGraw Hill
3. Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.

REFERENCE BOOKS:

1. Bralla, Design for Manufacture handbook, McGraw Hill, 1999.
2. Boothroyd, G, Hertz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
3. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
4. Fixel, J. Design for the Environment McGraw Hill., 1996. 8. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub.1996.


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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Design and evaluate components for manufacturability, strength, and process efficiency.
2. Apply design principles to develop suitable forms for forging, extrusion, and sheet metal working processes.
3. Apply machining-friendly design principles to optimize manufacturing and productivity.
4. Ability to design and evaluate cast components with proper tolerances and manufacturability
5. Understand eco-friendly design principles emphasizing sustainability and environmental responsibility and Perceive the principles and steps for designing products for economical production.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	3	2	2	1	1	–	–	–	2	2	2	3
CO2	3	3	3	2	2	1	–	–	–	–	1	2	1	3
CO3	3	2	3	2	2	1	–	–	–	–	2	2	2	2
CO4	3	3	3	2	2	1	–	–	–	–	2	2	3	2
CO5	2	2	3	1	2	2	3	1	–	–	1	3	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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VALUE ENGINEERING
(PROFESSIONAL ELECTIVE -II-4)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E24	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Introduce the basic concepts, history, and importance of Value Engineering in industry.
2. Explain the **concepts of value, cost, and worth** using function analysis methods.
3. Familiarize students with the **Value Engineering job plan** and its systematic phases.
4. Develop skills in applying **VE tools and techniques** for cost reduction and value improvement.
5. Enable students to understand **implementation, management, and real-world applications** of Value Engineering.

COURSE CONTENT:**UNIT I:****(L-10)**

Introduction to Value Engineering: Definition and history of value engineering, – Purpose and benefits of value studies, Role of VE in industry and management decision-making

UNIT II:**(L-10)**

Value Analysis and Function Evaluation: Concepts of “value”, “cost”, “worth”, Function analysis and evaluation methods, Basics of the FAST (Function Analysis System Technique) diagram.

UNIT III:**(L-10)**

Value Engineering Job Plan: Phases of VE job plan (information, function analysis, creative, evaluation, implementation), Steps and techniques for conducting VE studies, Project selection and application of VE methodology.

UNIT IV:**(L-10)**

Techniques and Tools of Value Engineering : Mapping functions to costs, Decision matrices and alternative development, Quantitative evaluation of functions and cost analysis.



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UNIT V:**(L-10)**

Implementation and Management of VE: Organizing a VE programme within an enterprise, Managing VE teams and resources, Reporting results and follow-up actions.

Case Studies and Applications: Examples of VE in product design, process improvement, and service systems, Lessons from practical VE projects.

TEXT BOOKS:

1. Tufty, H.G., *Compendium on Value Engineering*, The Indo-American Society, Bombay, 1983.
2. Park, Richard J., *Value Engineering: A Plan for Invention*, CRC Press, 1999.
3. Miles, Lawrence D., *Techniques of Value Analysis and Engineering*, McGraw-Hill, 1972.

REFERENCE BOOKS:

1. Dell'Isola, Alphonse J., *Value Engineering: Practical Applications*, RS Means / Wiley, 2002.
2. Kaufman, Jerome J. and Woodhead, Roy, *Value Engineering for the Practitioner*, North Carolina State University, 1980.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1.	Describe the principles, purpose, and benefits of Value Engineering in engineering and management decisions.
2.	Analyze functions using value, cost, worth concepts and construct basic FAST diagrams.
3.	Apply the VE job plan to select projects and carry out value studies systematically.
4.	Use VE tools such as function–cost mapping and decision matrices to evaluate alternatives.
5.	Demonstrate the application of VE through case studies in product design, processes, and services.

Mapping of Course Outcomes with Program Outcomes:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO1 2	PSO 1	PSO2
CO1	3	2	–	–	–	2	–	–	–	–	–	1	1	1
CO2	3	3	2	2	1	–	–	–	–	–	–	1	1	1
CO3	2	3	3	2	2	–	–	–	1	1	2	1	1	1
CO4	2	3	3	2	2	–	–	–	–	–	3	1	1	1
CO5	2	2	2	2	1	2	1	1	2	2	3	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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FUEL CELL TECHNOLOGY

(PROFESSIONAL ELECTIVE -II-5)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Provide a fundamental understanding of fuel cell principles, chemistry, and electrochemical energy conversion.
2. Familiarize students with hydrogen and hydrocarbon fuels, fuel impurities, and suitable storage/handling methods.
3. Analyze fuel cell electrochemistry, voltage losses, performance curves, and efficiency characteristics.
4. Develop knowledge of PEMFC and SOFC system components, construction, operating conditions, and modelling.
5. Introduce fuel processing and reforming technologies for sustainable fuel cell applications.

Unit-I

(L-12)

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Unit-II

(L-12)

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others, liquid hydrogen and compressed hydrogen-metal hydrides, alkaline fuel cell.

Unit-III

(L-12)

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarisation curve, fuel cell efficiency, Tafel equation, exchange currents, current density, power density, potential and thermodynamics of fuel cell, Introduction to direct methanol fuel cell.

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates. Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Unit-IV

(L-12)

Solid oxide Fuel Cells: Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarisation, testing of electrodes, cells and short stacks, Cell, stack and system modelling.

Unit-V

(L-12)

Fuel processing: Direct and indirect internal reforming, Reformation of hydrocarbons by steam, CO₂ and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs.


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Text Books:

1. Hoogers G., Fuel Cell Technology Handbook, CRC Press, 2003.
2. Karl Kordesch & Gunter R. Simader, Fuel Cells and Their Applications, 1st ed., VCH Publishers, NY, 2001.

Reference Books:

1. Barbir F., PEM Fuel Cells: Theory and Practice, 2nd edition, Elsevier/Academic Press, 2013.
2. Subhash C., Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, Elsevier Advanced Technology, 2003.
3. O'Hayre R. P., S. Cha., W. Colella., F. B. Prinz., Fuel Cell Fundamentals, Wiley, NY, 3rd edition, 2016.

COURSE OUTCOMES: After successful completion of this course, the students will be able to

1. Explain fuel cell basics, their need, working principles, efficiency and thermodynamic limits.
2. Describe fuels used in fuel cells, impurities and storage techniques.
3. Analyze electrochemical performance characteristics including polarization, kinetics & voltage losses.
4. Compare components, materials and operational parameters of PEMFC and SOFC systems.
5. Evaluate various reforming processes, impurity removal and renewable fuel integration for fuel cells.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO3	2	3	2	2	1	1	1	1	1	1	1	3	3	3
CO4	2	2	3	2	1	1	1	1	1	1	1	3	3	3
CO5	1	2	3	3	2	1	2	1	1	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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ROBOTICS

(PROFESSIONAL ELECTIVE -II-6)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-5-5-R25E26	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The vital learning objectives of this course are:

1. To provide fundamental conceptual knowledge about different robot configurations based on coordinate system and mode of control criteria along with an industrial robot's performance characteristics.
1. To give insight into the kinematics aspects of industrial robots and developing kinematic models by utilizing homogenous transformation matrixes including DH matrix.
2. To develop mathematical models and to devise control strategies of robotic systems by making use of transfer functions.
3. To dwell on powering the robot manipulator and to study the sensors used in the control action of robot manipulators including vision sensors.
4. To familiarize with the industrial applications and programming methods of industrial robots including robot work cell design.

COURSE CONTENT:**UNIT I:****(L-12)**

Introduction: Overview - Classification of Robots – Classification by Coordinate System – Cartesian, Cylindrical, Spherical and Jointed Arm Robots – Classification by Control Method – Non – servo controlled, Servo Controlled, Point – to – point and Continuous path controlled robots – Major Components of a Robot – Robot specifications and Performance parameters – Accuracy – repeatability – Precision and Work volumes of different robot geometries

UNIT II:**(L-12)**

Kinematics of Robotic Manipulators – Kinematic links and joints – General description of robot manipulators – Homogeneous transformation (HT) of objects – Forward and Inverse kinematics of two – degrees – of – freedom (DOF) Planar manipulators – Robot hand – Roll – Pitch – Yaw (RPY) Transformations – Denavit – Hartenberg (DH) Representations – Kinematic solutions by DH matrix.

UNIT III:**(L-12)**

Mathematical Modelling of a Robotic system – Robot control system – Different types of controllers – On – off, Proportional, Integral, Derivative and PD and PID controllers – Control Systems – Closed – loop and Open – loop control systems – Transfer functions – Applications of transfer functions in the context of robot controllers.

UNIT IV:**(L-12)**

Robot Drives, Sensors and Grippers – Powering the manipulator – Hydraulic, Pneumatic and Electric Drives – Robot Sensors – Types – Position, velocity, force and tactile range and proximity sensors – Robot vision – Robot grippers – Types of end – effectors/grippers – mechanical, pneumatic and magnetic grippers.

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UNIT V:**(L-12)**

Industrial Applications of Robots and Robot Programming – Applications – Material handling, Machine loading and unloading, Assembly and Inspection – Programming by teach box (or pendant) – On – line and offline programming methods – Robot work cells.

TEXT BOOKS:

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, 'Industrial Robotics Technology, Programming and Applications', Mc Graw Hill Book company, 1986
2. Bernard Hodges, 'Industrial Robotics', Second Edition, Jaico Publishing House, 1993
3. Deb S.K., Deb.S., "Robotics Technology and Flexible Automation", Tata McGraw-Hill Education Private Limited, 2009.
4. Gonzalez K.S.F.U.R.C. and Lee C.S.G., Robotics – Control – Sensing, Vision, and Intelligence , McGraw-Hill Book Company (July 1987)
5. Paul R.P., " Robot Manipulators: Mathematics, Programming and Control "The MIT Press (November 2, 1981)

REFERENCE BOOKS:

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesley Longman Inc. International Student edition, 1999
2. Mark W. Sponge & Vidya Sagar M., "Robot Dynamics and Control", Wiley; 1st edition (1989)
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Understand the basic anatomy of industrial robots, robot configurations, their work volumes, and their performance characteristics.
2. Acquaint with kinematic modelling of 2 – DOF and 3 – DOF robot manipulators along with robot hand transformations utilizing DH matrix.
3. Develop the mathematical modelling of control strategies – Proportional(P), Derivative(D), Integral (I), PD, PI and PID controllers – of industrial robots and to study the significance of transfer functions in control strategies.
4. Understand the sensing, powering and handling capabilities of industrial robots including machine vision sensors – drives, sensors, and grippers/end – effectors.
5. Write simple robot programs to perform tiny industrial tasks and to select suitable/correct robot geometry for a specific industrial application.



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CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	3	2	1	1	1	1	1	2	1	1	3	1
CO2	3	2	3	2	1	1	1	1	1	2	1	1	3	1
CO3	3	2	3	2	1	1	1	1	1	2	1	1	3	1
CO4	3	2	3	2	1	1	1	1	1	2	1	1	3	1
CO5	3	2	3	2	1	1	1	1	2	3	1	1	3	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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B. Tech. (Mechanical Engineering)
Semester VI (Third Year)

Code		Category	Course Title	Hours/Week			Total	Credits	Marks		
Department	University			L	T	P			CIE	SEE	Total
ME 5601C	7-5-6-01R25	ME-PC	Machine Design	3	0	0	3	3	40	60	100
ME 5602C	7-5-6-02R25	ME-PC	Dynamics of Machinery	3	0	0	3	3	40	60	100
ME 5603C	7-0-6-R25M1	ME-ES	Elements of Quantum Computing	3	0	0	3	2	100	0	100
ME 5604E	7-5-6-R25E1	ME-PE	Professional Elective -III	3	0	0	3	3	40	60	100
ME 5605E	7-5-6-R25E2	ME-PE	Professional Elective -IV	3	0	0	3	3	40	60	100
ME 5606O	7-5-6-R25O1	ME-OE	Open Elective -I (MOOCS)	0	0	0	0	3	0	100	100
ME 5607L	7-5-6-R25P1	ME-PC	Dynamics Lab	0	0	3	3	1.5	40	60	100
ME 5608L	7-5-6-R25P2	ME-PC	Metrology Lab	0	0	3	3	1.5	40	60	100
ME 5609L	7-5-6-R25P3	ME-PC	Heat Transfer Lab	0	0	3	3	1.5	40	60	100
ME 5610K	7-5-6-R25KS	ME-IK	IKS-MOOCs	2	0	0	0	2	100	0	100
ME 5611S	7-5-6-R25S1	ME-SC	Design Thinking and Micro Project with Seminar *	1	0	2	3	0	0	100	100
TOTAL				18	0	11	27	23.5	480	620	1100
Students shall undergo summer Industrial Internships for a duration of six to eight (6-8) weeks during the summer vacation by completing 45 – 60 hours of work with at least 75% attendance, to be evaluated and reflected in 7 th semester.											
* Students shall do Micro Projects in Department Laboratories and Present their work as Seminars.											
The students have to choose open electives (OE-I, OE-II, OE-III, etc..) from other disciplines or departments. The student cannot opt for an open elective course offered by his own (parent) department/discipline.											
Students shall ensure that IKS MOOCs and IKS Mandatory courses are not same either in title and/or in syllabi.											

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MECHANICAL ENGINEERING

PROFESSIONAL ELECTIVE COURSES

Professional Elective - I (V Sem)	7-5-5-R25E11	Non-conventional Energy Sources
	7-5-5-R25E12	Welding Technology
	7-5-5-R25E13	Mechanical Vibrations
	7-5-5-R25E14	Product Design and Development
	7-5-5-R25E15	Biomedical Engineering
	7-5-5-R25E16	Geometric Modelling for CAD
Professional Elective – II (V Sem)	7-5-5-R25E21	Advanced Manufacturing Processes
	7-5-5-R25E22	Composite Materials
	7-5-5-R25E23	Design for Manufacturing and Assembly
	7-5-5-R25E24	Value Engineering
	7-5-5-R25E25	Fuel Cell Technology
	7-5-5-R25E26	Robotics
Professional Elective – III (VI Sem)	7-5-6-R25E11	Analysis and Control of Production Systems
	7-5-6-R25E12	Introduction to Drone Technology
	7-5-6-R25E13	Industrial Safety
	7-5-6-R25E14	Introduction to Turbo Machinery
	7-5-6-R25E15	Tool Design
	7-5-6-R25E16	Oil Hydraulics and Pneumatics
Professional Elective – IV (VI Sem)	7-5-6-R25E21	Power Plant Engineering
	7-5-6-R25E22	Refrigeration and Air-conditioning
	7-5-6-R25E23	Quality control and Reliability Engineering
	7-5-6-R25E24	Energy Management and Audit
	7-5-6-R25E25	Alternative fuels
	7-5-6-R25E26	Data Science for Mechanical Engineers
	7-0-6-R25CE1	Introduction to Semiconductor Manufacturing
Professional Elective – V (VII Sem)	7-5-7-R25E11	Additive Manufacturing
	7-5-7-R25E12	Mechatronics
	7-5-7-R25E13	Supply Chain Management
	7-5-7-R25E14	Maintenance Engineering and Management
	7-5-7-R25E15	Finite Element Method
	7-5-7-R25E16	Tribology
Professional Elective – VI (VII Sem)	7-5-7-R25E21	Project Management
	7-5-7-R25E22	Hybrid Electric Vehicles
	7-5-7-R25E23	Flexible Manufacturing Systems
	7-5-7-R25E24	Design and Analysis of Experiment
	7-5-7-R25E25	Artificial Intelligence and Machine Learning
	7-5-7-R25E26	Lean Manufacturing and Six Sigma



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MACHINE DESIGN**Credits: 3****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-01R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To impart the knowledge of statistical considerations in design, including probability distributions, tolerance analysis, and variation control to ensure reliability and quality in machine element design.
2. To enable students to understand the design principles of various types of mechanical springs, considering static and fluctuating loads, material selection, and spring performance criteria.
3. To develop analytical ability for selecting and designing rolling and sliding contact bearings based on load, life, lubrication, and failure considerations.
4. To provide in-depth understanding of gear design, focusing on spur and helical gears, force analysis, and strength evaluation under static and dynamic conditions.
5. To equip students with the ability to design key IC engine components such as pistons and connecting rods, considering stresses, forces, proportions, and material suitability.

COURSE CONTENT:**UNIT I:****(L-10)****STATISTICAL CONSIDERATIONS IN DESIGN:**

Frequency distribution, characteristics of frequency curves, measures of central tendency and dispersion, probability – probability distribution – normal curve – population combinations – design and natural tolerances.

UNIT II:**(L-10)****MECHANICAL SPRINGS:**

Spring Materials, Springs, Types of Springs, Terminology of Helical Springs, Styles of End, Stress and Deflection Equations, Series and Parallel Connections, Design of Helical Springs, Spring Design-Trial-and-Error Method, Design against Fluctuating Load, Concentric Springs, Optimum Design of Helical Spring, Surge in Spring, Helical Torsion Springs, Spiral Springs, Multi-Leaf Spring, Nipping of Leaf Springs.



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UNIT III:**(L-10)****ROLLING CONTACT BEARINGS:**

Bearings, Types of Rolling-contact Bearings, Static Load Carrying Capacity, Stribeck's Equation, Dynamic Load Carrying Capacity, Equivalent Bearing Load, Design for Cyclic Loads and Speeds, Bearing Failure-Causes and Remedies, Lubrication of Rolling Contact Bearings, Selection of radial ball bearings.

SLIDING CONTACT BEARINGS:

Classification of bearings Hydrodynamic lubricated bearings; Materials for sliding contact bearings; Lubricants – Properties and their selection Terminology used in hydrodynamic journal bearings. Design procedure for journal bearings – Heat in bearings. Design of collar bearings.

UNIT IV:**(L-10)****SPUR GEARS:**

Gear Drives, Classification of Gears, Terminology of Spur Gears, Force Analysis, Design of spur gears – Lewis equation, Check for dynamic load and wear load, Gear wheel proportion.

HELICAL GEARS:

Helical Gears, Terminology of Helical Gears, Design of Helical Gears, Wear Strength of Helical Gears, Force Analysis.

UNIT V:**(L-10)****DESIGN OF IC ENGINE COMPONENTS:**

Pistons: forces acting on pistons – Construction, Design and proportions of Pistons.
Connecting rod: Thrust in connecting rod – stress due to whipping action on connecting rod ends, Design of Connecting rod.

TEXT BOOKS:

1. Bhandari V.B.: Design of Machine Elements, Third Edition, TataMcGrawHill, 2010.
2. Shigley J. E and Mischke, C.R.: Mechanical Engineering Design, Fifth Edition, McGraw Hill International, 1989.
3. Lal G.K., Vijay Gupta, Venkata Reddy N: Fundamentals of Design and Manufacturing, Alpha Science International, 2005
4. Deutschman D. Michels, W.J. and Wilson, C.E, Machine Design Theory and Practice, MacMillan, 1992

REFERENCE BOOKS:

1. Spottes, M.F., Design of Machine Elements, Prentice – Hall India, 1994
2. R.L. Norton, Mechanical Design – An integrated Approach, Prentice Hall, 1998



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3. Allen Strickl and Hall, Alfred R. Holowenko, Herman G. Laughlin: Machine Design, Schaum Series, Tata McGrawHill, 2010.
4. Sharma P.C. and Aggarwal D.K.: Machine Design, S.K.Kataria and Sons, 1997
5. Jain R.K.: Machine Design , Fifth Ediiton, Kanna, 1988.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Apply statistical methods and probability concepts to determine design tolerances and ensure reliability in mechanical component design.
2. Design and analyze various types of mechanical springs under static and dynamic loading conditions for optimum performance and safety.
3. Select suitable bearings and design rolling and sliding contact bearings considering load, lubrication, and failure mechanisms.
4. Design spur and helical gears using analytical methods, checking for strength, dynamic loads, and wear to ensure durable gear performance.
5. Design major IC engine components such as pistons and connecting rods based on functional requirements, stress analysis, and performance considerations.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	2	2	1	1	1	1	1	1	1	2	3	2
CO2	3	3	3	2	2	1	1	1	2	1	2	2	3	2
CO3	3	3	3	2	2	1	1	1	1	1	2	2	3	2
CO4	3	3	3	2	2	1	1	1	2	1	2	2	3	2
CO5	3	3	3	2	2	1	1	1	2	2	2	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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DYNAMICS OF MACHINERY**Credits: 3****Assessment: 40****+60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-02R25	ME

Pre-Requisites: Engineering Mechanics, Mechanics of solids & Kinematics of Machinery**COURSE OBJECTIVES:** The main learning objective of this course is

1. To apply the principles of friction in the analysis and design of brakes, clutches, and dynamometers.
2. To analyze engine turning moment diagrams, flywheel energy storage, and governing mechanisms for speed control.
3. To study the concept of gyroscopic motion and its effects on ships, airplanes, and vehicles.
4. To acquire knowledge on balancing rotating and reciprocating masses to minimize vibration and ensure smooth machine operation.
5. To understand the fundamentals of mechanical vibrations and their control in single- and multi-degree freedom systems.

COURSE CONTENT:**UNIT I:****FRICTION:**

Friction of Pivot and Collar Bearing, Uniform Pressure, Uniform Wear, Brakes and Dynamometers: Block, Band Brake, Band and Block Brake, Internal Expanding Brake, Classification of Absorption and Transmission Dynamometers, General description and methods of operation. Friction Clutches, Single Disc, Multiple Disc Clutch.

UNIT II:**TURNING MOMENT AND FLYWHEELS:**

Turning Moment Diagram for a Four Stroke Cycle IC Engine and a Multicylinder Engine, Fluctuation of Energy, Fluctuation of Speed, Energy Stored in a Flywheel, Flywheel in Punching Press.

GOVERNORS:

Types of Centrifugal Governors- Watt, Porter, Proell, Hartnell, Hartung Governors. Isochronous Governor, Hunting. Effort and Power of the Governors, Controlling Force.

UNIT III:**GYROSCOPIC COUPLE:**

Gyroscopic Couple, Effect of Gyroscopic Couple on an Aeroplane, Effect of Gyroscopic Couple on a Naval Ship during Steering, Pitching, Rolling, Stability of a Four-Wheeler Moving in a Curved Path.



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UNIT IV:**BALANCING OF ROTATING MASSES:**

Balancing of Rotating Masses, Balancing of Several Masses Rotating in the Same Plane, Balancing of Several Masses Rotating in Different Planes using Analytical and Graphical Methods.

BALANCING OF RECIPROCATING MASSES:

Partial Balancing, Partial Balancing of Locomotives, Variation of Tractive Force, Swaying Couple, Hammer Blow. Balancing of Primary Forces of Multi-cylinder In-line Engines, Balancing of Secondary Forces of Multi-cylinder In-line Engines. Practical Methods of balancing of rotors.

UNIT V:**VIBRATIONS:**

Free and forced vibration of single degree of freedom system, Role of damping, whirling of shafts and critical speeds. Free, forced and damped vibrations. Vibration Isolation and Transmissibility, Transverse vibrations of beams with concentrated and distributed loads, Dunkerly's method, and Raleigh's method. Torsional vibrations - two and three rotor systems

TEXT BOOKS:

1. Theory of Machines : S.S.Rathan , 5th Edition, McGraw-Hill Education (India) Private Limited.
2. Theory of Machines : R.S.Khurmi. 14th Edition, S. Chand Publishing.
3. Theory of Machines and Mechanisms: PL. Ballaney, 25th Edition, Khanna Publishers.
4. Mechanisms and Machine theory : J.S.Rao and R.V.Dukkipati., 2nd Edition, New Age International Publishers.

REFERENCE BOOKS:

1. Theory of Machines and Mechanisms : Shigley J.E, 5th edition Oxford University Press,
2. Mechanisms and Dynamics of Machinery : Hamilton Mabie H. and F. W. Ocvirk /Oxford University Press.
3. Mechanisms and Machine theory : J.S.Rao and R.V.Dukkipati., 2nd Edition, New Age International Publishers.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Apply the fundamental principles of friction in the analysis and design of brakes, clutches, and dynamometers.
2. Analyze engine turning moment diagrams, flywheel energy storage, and governing mechanisms for speed control.



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3. Explain the concept of gyroscopic motion and its effects on various engineering systems like ships, airplanes, and vehicles.
4. Balance rotating and reciprocating masses to minimize vibration and ensure smooth machine operation.
5. Evaluate the fundamentals of mechanical vibrations and their control in single- and multi-degree freedom systems.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	3	3	2	2	2	1	1	2	2	1	3	3	2
C02	3	3	3	3	2	2	1	1	2	2	1	3	3	2
C03	3	3	2	3	2	1	1	1	2	2	1	3	3	2
C04	3	3	3	3	2	2	1	1	2	2	1	3	3	2
C05	3	3	3	3	3	1	1	1	2	2	1	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially



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ELEMENTS OF QUANTUM COMPUTING**Credits: 3****Assessment: 100+0**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-0-6-R25M1	ME

Pre-Requisites: None**Course Objectives**

1. To introduce the basic principles of quantum mechanics relevant to computing.
2. To differentiate between classical and quantum computation models.
3. To understand qubits, superposition, entanglement, and quantum gates.
4. To study basic quantum algorithms and their real-world applications.

Course Content:**UNIT – I:**

Evolution of computation: classical to quantum paradigm, Limitations of classical computation, Basic principles of quantum mechanics relevant to computation.
Introduction to Quantum Computing: Bits Vs Qubits, Classical Vs Quantum logical operations

UNIT - II

Quantum states and qubits, Superposition principle and quantum measurement. Quantum entanglement and its importance.
Quantum gates: Pauli, Hadamard, Phase, CNOT, Toffoli. Bloch sphere representation of qubit states.

UNIT - III

Qubit: Physical implementations of Qubit. Qubit as a quantum unit of information. The Bloch sphere
Quantum Circuits: single qubit gates, multiple qubit gates, designing the quantum circuits. Bell states.

UNIT - IV

Quantum Algorithms: Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor's factorization algorithm, Grover's search algorithm.

UNIT - V

Noise and error correction: Graph states and codes, Quantum error correction, fault-tolerant computation. Quantum Information and Cryptography: Comparison between classical and quantum information theory. Quantum Cryptography, Quantum teleportation

TEXT BOOKS:

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge


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REFERENCE BOOKS:

1. Quantum Computing for Computer Scientists by Noson S. Yanofsky and Mirco A. Mannucci.
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information,
3. Vol. I: Basic Concepts, Vol II
4. Basic Tools and Special Topics, World Scientific. Pittenger A. O., An Introduction to Quantum Computing Algorithms

Course Outcomes

1. Understand basic principles of quantum mechanics relevant to computation.
2. Understand basics of quantum states, qbit and gates.
3. Understand physical implementation of Qubit
4. Understand Quantum algorithms and their implementation
5. Understand The Impact of Quantum Computing on Cryptography

Mapping of Course Outcomes with Program Outcomes:														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1			1	2	1	1		1	1	1	2
CO2	1	2	2	1	1	1	2		1	1	1	2		
CO3	2	1	3	3	1	1	1				1	3	1	3
CO4	1	2	3	3	1	1	1	1		1	1	3	1	3
CO5	2	2	2	2	2	1	1	1	1		1	3	1	3

1 – Slightly; 2 - Moderately; 3 – Substantially


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DYNAMICS LAB**Credits: 1.5****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	0-0-3	7-5-6-R25P1	ME

Pre-Requisites: Students should have a basic understanding of rotational motion, torque, angular momentum, and moment of inertia, along with knowledge of Hooke's Law, spring stiffness. Familiarity with simple harmonic motion, torsional oscillations, damping, and natural/damped frequencies is required, as well as basic measurement techniques for deflection, force, and period.

COURSE OBJECTIVES: The main learning objective of this course is

1. To provide practical understanding of gyroscopic effects, mass moment properties, and dynamic behaviour of rotating mechanical components.
2. To enable students to experimentally determine mechanical properties such as stiffness, elastic modulus, radius of gyration, and mass moment of inertia using standard testing methods.
3. To develop the ability to analyze vibrations in mechanical systems by determining damping characteristics, natural frequency, and critical speed of shafts.
4. To familiarize students with cam mechanisms and enable them to analyze cam profiles along with SVAJ (Displacement, Velocity, Acceleration, and Jerk) characteristics.
5. To enhance students' skills in conducting experiments, recording precise measurements, analysing results, and preparing technical reports in accordance with engineering standards.

Course Content:

Study of gyroscope, Connecting rod dynamics, Spring stiffness, Beam elasticity, Torsional pendulum, Cam Profile, Critical Speed and Damped vibrations with practical measurements and analysis.

List of Experiments:

Experiment 1: Analyze the Gyroscopic Couple of rotating systems

Experiment 2: Determination of Radius of Gyration of Connecting Rod

Experiment 3: Determination of Stiffness of a Spring

Experiment 4: Determination of Elastic Modulus of a Beam

Experiment 5: Determination of Mass Moment of Inertia of a Disc

Experiment 6: Study and analyze the Damped Vibrations, Damping Factor and Damped Natural Frequency of a system

Experiment 7: Analysis of Cam and its SVAJ (Displacement, Velocity, Acceleration, and Jerk) characteristics.

Experiment 8: Determination of mass moment of connecting rod

Experiment 9: Determination of Critical Speed of a shaft



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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to

1. Analyze gyroscopic effects and determine the gyroscopic couple in rotating systems.
2. Determine the radius of gyration and mass moment of inertia of Connecting rod.
3. Determine Elastic modulus of a beam, Stiffness of a Spring and Mass moment of inertia of a disc.
4. Analyze the vibration system and determine the damped Vibrations, damping Factor and damped natural frequency. Also, determine the critical speed of a shaft.
5. Analyze the Cam Profile, SVAJ Characteristics (Displacement, Velocity, Acceleration and Jerk) and Critical Speed of a shaft.

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	3	2	1	1	1	1	1	1	1	3	1
CO2	3	3	1	3	2	1	1	1	1	1	1	1	3	1
CO3	3	3	1		2	1	1	1	1	1	1	1	3	1
CO4	3	3	1	3	2	1	1	1	1	1	1	1	3	1
CO5	3	3	1	3	2	1	1	1	1	1	1	1	3	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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METROLOGY LAB**Credits: 1.5****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	0-0-3	7-5-6-R25P2	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To understand the fundamental principles of dimensional and geometric metrology, including linear, angular, and form measurements.
2. To familiarize students with the construction, working, and applications of various precision measuring instruments such as micrometres, slip gauges, sine bars, V-blocks, and comparators.
3. To develop the ability to perform accurate measurements of components like tapers, gears, screw threads, angles, effective diameters using standard methods.
4. To interpret, analyse, and evaluate measurement data for assessing accuracy, tolerances, and quality of manufactured parts.
5. To enhance problem-solving, teamwork, and technical documentation skills through laboratory experiments in inspection and quality control.

List of Experiments

1. Measurement of Taper plug gauge using rollers, slip gauges and micrometre
2. Measurement of internal taper of ring gauge using sphere and cylinders
3. Study of measuring instruments
4. Measurement of spur gear
5. Measurement of taper ring gauge using spheres and depth micrometre
6. Sine bar (Angle measurement of a taper plug gauge)
7. Inspection of drill jig
8. Straightness testing- wedge method
9. Measurement of angle of V-Block
10. Measurement of plug screw by 3 – wire method
11. A) Measurement of effective diameter (Two -wire method) of a screw tap
B) Radius measurement of a partial cylinder


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COURSE OUTCOMES: After successful completion of the course, the student will be able to:

6. Perform accurate measurements of length, angle, and dimensional tolerances using vernier callipers, micrometres, dial gauges, and height gauges.
7. Understand and apply principles of linear and angular measurements, including calibration of instruments.
8. Measure and interpret surface roughness and characteristics using profilometers and comparators.
9. Evaluate geometric tolerances such as flatness, straightness, and roundness using gauges and inspection tools.
10. Analyse data obtained from measurements to assess accuracy, precision, and uncertainty.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	3	2	1	1	1	1	1	1	2	1	1
CO2	2	2	1	2	3	1	1	2	1	1	1	1	1	1
CO3	2	3	1	3	2	1	1	1	1	1	1	2	1	1
CO4	2	3	1	3	2	1	2	1	1	1	1	2	1	1
CO5	2	3	1	3	2	1	2	2	2	1	2	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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HEAT TRANSFER LAB**Credits: 1.5****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	0-0-3	7-5-6-R25P3	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To provide practical knowledge of conduction, convection, and radiation heat transfer phenomena.
2. To develop experimental skills for measuring thermal properties and evaluating system performance.
3. To enable students to verify theoretical concepts through laboratory experimentation.
4. To train students in data analysis, result interpretation, and performance comparison.
5. To impart knowledge on the operation and testing of heat exchangers and other thermal devices.

List of Experiments

1. Test on the Thermal conductivity of a metal rod.
2. Test on the Thermal conductivity of the slab.
3. Test on Emissivity Measurement Apparatus.
4. Test on Lagged Pipe Apparatus.
5. Test on Stefan-Boltzmann Apparatus.
6. Test on the Finned tube heat exchanger.
7. Test on Natural Convection Apparatus.
8. Test on Forced Convection Apparatus.
9. Test on the Vapour compression test rig.
10. Test on a parallel flow and counter flow heat exchanger
11. Test on thermal conductivity of liquids.


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COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Demonstrate an understanding of various heat transfer modes through experiments.
2. Conduct experiments on conduction, convection, and radiation to evaluate heat transfer rates.
3. Analyze experimental data and compare results with theoretical and empirical correlations.
4. Prepare technical reports and present findings effectively with engineering reasoning.
5. Evaluate the performance of different types of heat exchangers.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	3	1
CO2	3	3	2	2	1	1	1	1	1	1	1	2	3	2
CO3	3	3	3	3	1	1	1	1	1	1	1	2	3	2
CO4	3	3	3	2	2	1	1	1	1	1	1	2	3	3
CO5	3	3	3	3	2	1	1	1	2	3	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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DESIGN THINKING AND MICRO PROJECT WITH SEMINAR**Credits: 0****Assessment: 0 +100**

Semester	L-T-P	Course Code	Branches
VI	1-0-2	7-5-6-R25S1	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Introduce the fundamental principles of design thinking, emphasizing its importance, key stages, and real-world applications in innovative problem-solving.
2. Develop the ability to generate creative ideas and employ brainstorming and ideation techniques for addressing engineering and product design challenges.
3. Enable students to identify user needs, define clear design specifications, and evaluate the technical and economic feasibility of proposed design solutions while adhering to relevant standards.
4. Train students in developing, testing, and refining prototypes, ensuring considerations of usability, safety, reliability, and manufacturability in the design process.
5. Cultivate professional ethics, a sense of responsibility, and commitment to codes and standards throughout all phases of product design and development.

COURSE CONTENT:**Concept of Design Thinking:**

What is design thinking, Need for Design Thinking, Objective of Design Thinking, Three Core Elements of Design Thinking. Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – Empathize, Define, Ideate, Prototype, Test.

Engineering Design:

What is designing? , The process of Design, design by evolution, Identification and analysis of need, True need, Specifications, Standards of performance, use of checklists, Morphological Analysis, Brainstorming, measure of physical realizability, Designing for shipping, handling and installation; Design considerations, Design tools and resources, Design Engineer's Professional Responsibilities; Standards and Codes.

“Each student is required to prepare and present an individual product design concept, participate in a group/ individual micro-project, and collectively deliver the outcomes through a seminar.”


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TEXT BOOKS:

1. Fundamentals of Design and Manufacturing, G. K. Lal, N. Venkata Reddy, Vijay Gupta, Alpha Science International Ltd. / Narosa Publishing House, New Delhi. 2005 Edition.
2. Fundamentals of Design & Manufacturing by R. S. Vaishwanar (Jain Brothers), 2020 Edition.

REFERENCE BOOKS:

1. Design Thinking: Understand – Improve – Apply, Hasso Plattner, Christoph Meinel, and Larry Leifer, Springer, Berlin, 2nd Edition, 2016.
2. Engineering Design: Principles, Concepts and Applications, K. L. Narayana, P. Kannaiah, and K. Venkata Reddy, New Age International Publishers, New Delhi, Revised Edition, 2018.
3. Product Design and Development, Karl T. Ulrich and Steven D. Eppinger, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7th Edition, 2020.
4. Engineering Design: A Systematic Approach, Gerhard Pahl and Wolfgang Beitz, Springer-Verlag, London, 3rd Edition, 2007.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand what design thinking is, why it is needed, and its main elements and stages with examples.
2. Use brainstorming and creative tools to suggest new ideas for solving problems.
3. Identify and analyze true needs, specifications, and feasibility while following standards in design.
4. Prepare and test simple prototypes, considering handling, installation, safety, and reliability.
5. Follow professional responsibilities by using codes, standards, and ethics in product design.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	1	1	1	1	1	2	1	2
CO2	3	3	3	3	2	2	1	1	1	1	1	2	1	2
CO3	3	3	3	3	2	2	2	1	1	1	2	2	1	2
CO4	3	3	3	3	2	2	2	1	1	1	2	2	1	2
CO5	3	3	3	3	2	2	2	2	1	1	2	2	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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ANALYSIS AND CONTROL OF PRODUCTION SYSTEMS (PROFESSIONAL ELECTIVE -III-1)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E11	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Understand production systems, manufacturing paradigms, and modern approaches such as lean and agile manufacturing.
2. Analyze facility location and layout problems using qualitative and computer-based techniques.
3. Apply planning tools such as forecasting, aggregate planning, and assembly line balancing for efficient operations.
4. Develop scheduling solutions for job shop and flow shop environments using sequencing and priority rules
5. Gain knowledge of controlling techniques including project management tools and advanced production control systems.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

The Production Paradigm – Production as a System – Types of Production Systems – Job type, Batch type, flow type and Project type – Group technology – Lean and Agile manufacturing

UNIT II:**(L-12+ P-0 =12)**

Facility Location and Layout – Multi plant location – Locational dynamics – use of REL charts and Travel charts – Computer based layout technique viz. CRAFT, CORELAP etc.

UNIT III:**(L-12 + P-0 =12)**

Planning – Manufacturing and Service Strategies – Aggregate Planning – Graphical Analysis - Forecasting – Moving Average, Exponential Smoothing. Assembly Line Balancing – Heuristics for Line Balancing.

UNIT IV:**(L-12 + P-0 =12)**

Operations Scheduling – Job shops and flow shops: Sequencing n jobs – 2 machines, n jobs 3 machines, n jobs m machines – 2 jobs m machines. Priority Scheduling rules – Criteria and effectiveness – “Traveling salesman” Problem.

UNIT V:**(L-12 + P-0 =12)**

Controlling – Project planning and Controlling with PERT / CPM – MRP, JIT, KANBAN systems – LOB technique – MRP-II



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TEXT BOOKS:

1. Adam and Ebert : Production and Operations Management, 5th Edition, Prentice Hall, 1992
2. Buffa E S : Modern Production Management, 8th Edition, Wiley-India, 2010.

REFERENCE BOOKS:

1. Groover M.P.: Automation, Production Systems and CIM, 3rd Edition, Prentice Hall, 2007.
2. Joseph Monks: Operations Management, 3rd Edition, McGraw-Hill, 1987.
3. Seetharama L. Narasimhan, Dennis W. McLeavey, Peter Billington: Production Planning and Inventory Control, 2nd Edition, Prentice Hall, 1995.
4. Elsayed A. Elsayed, Thomas O. Boucher: Analysis and Control of Production Systems, 2nd Edition, Prentice Hall, 1994.

Course Outcomes (CO): After successful completion of the course, the student will be able to:

1. Explain production systems, group technology, and modern manufacturing paradigms such as lean and agile manufacturing.
2. Analyze and design facility location and layout problems using REL charts, travel charts, and computer-based layout techniques.
3. Apply planning and forecasting techniques, aggregate planning methods, and assembly line balancing heuristics.
4. Solve operations scheduling problems for job shops and flow shops using sequencing rules and optimization techniques.
5. Apply controlling tools such as PERT/CPM, MRP, JIT, Kanban, LOB, and MRP-II for effective production management.

Mapping of Course Outcomes with Program Outcomes:													
PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO1	PSO2
3	2	1	1	2	1	2	1	2	2	1	2	2	1
3	3	2	2	3	1	1	1	1	1	1	2	3	1
2	3	3	3	3	2	1	1	2	2	1	2	3	2
2	2	2	3	3	2	2	2	3	3	2	3	3	2
2	1	1	2	2	3	3	3	2	2	3	2	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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INTRODUCTION TO DRONE TECHNOLOGY (PROFESSIONAL ELECTIVE -III-2)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E12	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. To understand the basics of drone concepts
2. To learn and understand the fundamentals of design, fabrication and programming of drone
3. To impart the knowledge of an flying and operation of drone
4. To know about the various applications of drone
5. To understand the safety risks and guidelines of fly safely

COURSE CONTENT:**UNIT I: (L-12 + P-0 =12)**

Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability

UNIT II: (L-12+ P-0 =12)

Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.

UNIT III: (L-12 + P-0 =12)

Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment- Drone controls Flight operations –management tool –Sensors-Onboard storage capacity Removable storage devices- Linked mobile devices and applications

UNIT IV: (L-12 + P-0 =12)

Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing

UNIT V: (L-12 + P-0 =12)


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The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms

TEXT BOOKS:

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.
2. Terry Kilby and Belinda Kilby, "Make: Getting Started with Drones", Maker Media, Inc, 2016
3. K.S. Fu, R.C. Gonzalez, C.G. Lee, *Robotics: Control, Sensing, Vision and Intelligence*, McGraw-Hill, 1987.

REFERENCE BOOKS:

1. John Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016
2. Završnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.
3. Muhammad Usman, *Quadcopter Modeling and Control with MATLAB/Simulink Implementation*, LAB University of Applied Sciences, 1st Edition, 2020.

Course Outcomes (COs):

1. Explain the fundamental concepts, terminology, history, and classifications of drones, and analyze their impact on business, entrepreneurship, and employability.
2. Identify and describe UAV components, configurations, energy sources, and levels of autonomy, and demonstrate understanding of drone assembly, programming methods, and flight stabilization techniques.
3. Evaluate and select appropriate drone platforms for various real-world applications such as agriculture, insurance, logistics, inspection, filming, and surveillance.
4. Operate a small drone in a controlled environment by applying knowledge of flight modes, sensors, control systems, on-board storage, and linked mobile applications.
5. Apply safety guidelines, aviation regulations, and licensing requirements while understanding emerging trends such as miniaturization, increased autonomy, and swarm technology in drones.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO2
CO1	3	2	1	1	2	1	2	1	2	2	1	2	2	1
CO2	3	3	2	2	3	1	1	1	1	1	1	2	3	1
CO3	2	3	3	3	3	2	1	1	2	2	1	2	3	2
CO4	2	2	2	3	3	2	2	2	3	3	2	3	3	2
CO5	2	1	1	2	2	3	3	3	2	2	3	2	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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INDUSTRIAL SAFETY
(PROFESSIONAL ELECTIVE -III-3)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E13	ME

Pre-Requisites: None**COURSE OBJECTIVES:(COs):**

1. To impart knowledge on industrial safety practices, hazard identification, fire prevention, and statutory safety regulations.
2. To introduce the fundamentals of maintenance engineering, maintenance organization, tools, and cost considerations.
3. To explain wear, lubrication, corrosion mechanisms, and their prevention methods in industrial equipment.
4. To develop systematic fault-tracing skills using decision tree techniques for mechanical and electrical systems.
5. To familiarize students with periodic and preventive maintenance procedures for mechanical and electrical equipment.

COURSE CONTENT:**UNIT I**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety colour codes. Fire prevention and fire fighting, equipment and methods.

UNIT II

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault-finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.



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UNIT V

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Text Books:

1. Kothari, D. P., & Nagrath, I. J. Industrial Safety, McGraw-Hill Education, New Delhi.
2. Lindley, R. H., & Higgins, L. R. Maintenance Engineering Handbook, McGraw-Hill.
3. Khanna, O. P. Industrial Engineering and Management, Dhanpat Rai Publications.
4. Jain, R. K. Production Technology, Khanna Publishers.

Reference Books:

1. Mobley, R. K. Maintenance Engineering Handbook, Butterworth-Heinemann.
2. Bansal, R. C. Hydraulic and Pneumatic Systems, Laxmi Publications.
3. Gupta, J. K., & Khurmi, R. S. A Textbook of Machine Design, S. Chand & Co.
5. Nagpal, G. R. Power Plant Engineering, Khanna Publishers.
6. Peel, D. A. Engineering Maintenance, Butterworths.

Course Outcomes (COs):

1. Identify industrial hazards and apply safety measures, fire-fighting techniques, and statutory safety regulations in industrial environments.
2. Explain the principles, functions, types, and economic aspects of maintenance engineering.
3. Analyze wear, lubrication, and corrosion phenomena and apply appropriate prevention and maintenance techniques.
4. Diagnose faults in mechanical, hydraulic, pneumatic, thermal, and electrical systems using systematic fault-tracing methods.
5. Plan and implement periodic and preventive maintenance schedules for machine tools, pumps, compressors, DG sets, and electrical motors.

Mapping COs with POs & PSOs:

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

1 – Slightly; 2 – Moderately; 3 - Substantially


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INTRODUCTION TO TURBO MACHINERY**(PROFESSIONAL ELECTIVE -III-4)****Credits: 3****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E14	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To introduce the fundamental principles governing the operation of turbomachines.
2. To explain the energy transfer process between fluid and rotating elements.
3. To differentiate between axial and radial flow machines and analyze their performance.
4. To familiarize students with the design and working of turbines, compressors, and pumps.
5. To apply thermodynamic and fluid dynamic concepts to evaluate turbomachine efficiency and performance.

Unit-I

(L-12)

Energy Transfer in Turbo Machine: Definition of a turbo machine. Parts of a Turbo machine. Comparison with positive displacement machines, Classification of turbomachines, Euler Turbine equation, Alternate form of Euler turbine equation and components of energy transfer. Degree of reaction, general expression for degree of reaction. Utilization factor, relation between utilization factor and degree of reaction. Condition for maximum utilization in Impulse, reaction and 50% reaction turbines. Velocity triangles for different values of degree of reaction. Comparison of impulse and reaction turbines

Unit-II

(L-12)

Impulse Hydraulic Turbines (Axial flow type): Classification of hydraulic turbines. Unit quantities and their significance. Pelton wheel and its Components. Velocity triangles and power. Effect of friction and condition for maximum efficiency. Design parameters and design of Pelton turbines. Turbine efficiencies and performance curves of Pelton wheel.

Unit-III

(L-12)

Reaction Hydraulic Turbines (Radial flow Type): Francis's turbine, types of reaction turbines, components of reaction turbine, velocity triangles, power and efficiency. Runner shapes for different blade speeds, design parameters and design of Francis turbine. Draft tube, types of draft tube, design of draft tube and functions of draft tube. Kaplan turbine, components, velocity triangles and design parameters.

Unit-IV

(L-12)

Steam Turbines (Both Axial and radial flow type): Classification of steam turbines with examples. Impulse staging and need for compounding; Velocity compounding, Pressure compounding and Pressure-velocity compounding. Velocity triangles, power and efficiency for impulse turbine, condition for maximum utilization factor. Effect of friction and blade angles on blade efficiency. Impulse reaction and reaction turbines and condition for maximum efficiency. Reheat factor and stage efficiency.



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Unit-V

(L-12)

Centrifugal Pumps: Centrifugal pumps, introduction and main part of the centrifugal pump. Work done and velocity triangles. Head developed, manometric head, suction head, delivery head and static head. Pump losses and efficiency. Minimum starting speed, net positive suction head, priming. Multistage centrifugal pumps and Cavitation in centrifugal pumps. Axial flow pumps, description, velocity triangles, work done on the fluid and energy transfer or head. Miscellaneous pumps like Jet pump, air lift pump and submersible pump.

Text Books:

1. B K Venkanna, "Fundamentals of Turbomachinery," PHI Learning Pvt Limited, 2009.
2. A Valan Arasu, "Turbomachines," Vikas Publishing House Pvt Ltd, 2009.
3. D. G. Shepherd, "Principles of Turbo Machinery," Macmillan Company, 1964.

Reference Books:

1. V. Ganesan, "Gas Turbines," Tata McGraw Hill Education Limited 3rd Edition, 2010.
2. S. M. Yahya, "Turbines Compressors and Fans," Tata McGraw Hill Education, 4th Edition, 2010
3. G. Gopalakrishnan, "A Treatise on Turbo machines," Scitech Publications (India) Pvt Ltd, 1st Edition, 2008
4. V. Kadambi and Monohar Prasad, "An introduction to energy conversion: Volume III –Turbomachinery," New Age International Private Limited, 2011.

COURSE OUTCOMES: After successful completion of this course, the students will be able to

1. Understand the fundamental principles of turbomachinery and energy transfer mechanisms.
2. Analyze velocity triangles and derive performance parameters for axial and radial flow machines.
3. Evaluate the performance characteristics of turbines, compressors, and pumps.
4. Apply thermodynamic and fluid flow concepts to optimize turbomachine operation.
5. Demonstrate knowledge of industrial applications and performance testing of turbomachinery.

CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO8	PO9	PO1 0	PO1 1	PO 12	PSO1	PSO 2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	3	2	2	1	1	1	1	1	1	1	1	3	2
CO3	3	2	3	2	1	1	1	1	1	1	1	2	3	2
CO4	2	3	3	2	1	1	1	1	1	1	1	2	3	3
CO5	2	2	2	3	2	1	1	1	1	2	2	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially


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TOOL DESIGN
(PROFESSIONAL ELECTIVE -III-5)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E15	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The vital learning objectives of this course are

1. To impart knowledge of principles and fundamentals of machining in order to understand the cutting tool geometry, types of cutting, mechanism of chip formation along with cutting force relations in relation to force diagram.
2. To describe intuitively how the temperature distribution in metal cutting would affect tool wear mechanism and consequently its useful life of working (tool – life) along with measurement of cutting forces by lathe tool dynamometer and selection of cutting fluids.
3. To understand the value of tool materials and its ability to stand up under the forces of wear and temperature in removing a from a workpiece in addition to abreast of cutting tool design of a lathe tool, milling cutter, and a broach tool.
4. To give insight into the topic on economics of machining from the point of view of minimum cost and maximum production rate criteria besides focusing on press tool design – design of blanking and piercing dies – collectively called press tool set.
5. To explain thoroughly basic principles of locating and clamping before attempting the solution of jigs and fixtures design problems alongside covering the design principles pertaining to drill jigs, turning, welding, and milling fixtures.

COURSE CONTENT:**UNIT I:****(L-12)**

Cutting Tools Classification – Nomenclature of single point cutting tool – Differences between orthogonal and oblique cutting – Mechanism of metal cutting – Types of chips – chip breakers – Forces acting on a tool – Merchant circle diagram – Velocity relations – specific energy in cutting.

UNIT II:**(L-12)**

Tool Wear – Tool life – Factors affecting tool life – Taylor's Tool life Equation – Tool wear mechanisms – Types of tool wear – Heat distribution in metal cutting – Measurement of temperature in metal cutting – Lathe tool Dynamometer – Cutting fluids – Selection and applications.

UNIT III:**(L-12)**

Cutting Tool Materials- Requirements of tool materials, advances in tool materials, HSS, Coated HSS, Carbides ,Coated Carbides, Ceramics, Cold pressed, Hot Pressed , Ceramic composites, CBN, Diamond- properties, Advantages and limitations; Specifications for Inserts and tool holders. Design of single point cutting tool and form tool for NC Lathe work- Design of profile milling cutter and broach tools


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UNIT IV: (L-12)

Press Working and Economics of Machining: Press working operations- Press selection and Tonnage- Centre of Pressure- Cutting forces and clearances for Die Design – Compound and Progressive Die, Strip layout. Costs associated with machining operations- Optimum cutting speed for minimum cost and maximum production, cutting speed for minimum cost in Turning.

UNIT V: (L-12)

Jigs & Fixtures- Uses- Locating devices, 3-2-1 principle of location – pin location- Radial location- ‘V’ location- Diamond locators. Types of clamping devices- principles of clamping. Design principles to Jigs & Fixtures – Drill Jigs, types- Drill Bushes, types- Fixtures for Turning, Milling and Welding.

TEXT BOOKS:

1. Fundamental of Tool Design – ASTME, Prentice Hall, New Delhi, 1987
2. Donaldson, Lecain and Goold - "Tool Design", McGraw Hill, New York, 1976

REFERENCE BOOKS:

1. BLJuneja and GSekhan, “Fundamental of Metal Cutting and Machine Tools“, 2nd Edition, New Age International Publishers, New Delhi, 2003
2. Milton C.Shaw, “Metal Cutting Principles”, 1st Edition, CBS Publishers & Distributors Pvt.Ltd, 2002.
3. Kempster, “In Introduction to Jig and Tool Design”, ELBS, 1974.
4. Herman W. Pollack, “Tool Design”, Prentice Hall, New Delhi.
5. Clade S. George Jr : Management For Business Industry, 1972

COURSE OUTCOMES: After successful completion of the course, the student will be able to:

1. Distinguish between orthogonal cutting and oblique cutting in addition to exhibiting fundamental knowledge in metal cutting theory, like, tool nomenclature, mechanism of chip formation, construction of Merchant’s circle diagram, velocity relations, and specific energy in cutting.
2. Acquaint with crater wear and flank wear of a turning tool and the associated temperature distribution in the production of chip along with understanding the significance of Taylor’s tool life equation in the selection of specific cutting tool material in machining of metals.
3. Understand the basic requirements of cutting tool material and to grasp the knowledge of advancements in cutting tool materials since 19th century and acquiring design strategies in designing a lathe tool, milling cutter, and a broach tool
4. Select optimum cutting conditions in minimizing the cost of production and enhancing the productivity of a manufacturing industry in addition to understanding the press work tool design approaches.
5. Adopt suitable design strategies, locating and clamping principles in the design of jigs and fixtures in relation to drilling, turning, milling and welding operations.


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Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	2	3	2	1	1	1	1	1	1	1	1	3	2
CO 2	3	2	3	2	1	1	1	1	1	1	1	1	3	2
CO 3	3	2	3	2	1	1	1	1	1	1	1	1	3	2
CO 4	3	2	3	2	1	1	1	1	1	1	1	1	3	2
CO 5	3	2	3	2	1	1	1	1	1	1	1	1	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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OIL HYDRAULICS AND PNEUMATICS (PROFESSIONAL ELECTIVE -III-6)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E16	ME

Pre-Requisites: Fluid Mechanics and Hydraulic Machinery

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to learn about

1. Functional requirements of a power transmission system for a given application.
2. System components and their properties.
3. Oil hydraulic pumps, actuators, and characteristics of actuators.
4. Control valves, hydraulic and pneumatic controllers.
5. Develop different types of circuits and their applications.

COURSE CONTENT:**UNIT I:****Introduction**

Functional Requirements of Power Transmission, Different Types of Power Transmission Systems and Their Combinations; Fundamentals of Oil Hydraulics And Pneumatics, Control Functions of Oil Hydraulic Systems; Comparison Between Mechanical, Oil Hydraulic, Pneumatic, and Electrical Power Transmission Systems; Advantages, Disadvantages, and Applications of Oil Hydraulic And Pneumatic Power Transmissions.

UNIT II:**System Components**

Hydraulic & Pneumatic Symbols As Per ISO/ANSI, Properties And Selection of Hydraulic Fluids, Filtration, Hydraulic Reservoirs, Accumulators, Intensifiers or Pressure Boosters, Seals, And Packing.

UNIT III:**Oil Hydraulic Pumps and Actuators**

Construction, The Working Principle and Operation of Rotary & Reciprocating Pumps Like Gear, Vane, Generated-Rotor, Screw, Axial Piston, Radial Piston, Pump Characteristics, Specifications and Selection of Pumps; Linear Actuators Like Ram Type, Telescopic, and Single Acting/Double Acting, Types of their Constructions, Types of Mountings, Cylinder Materials, Cushioning of Hydraulic Cylinders, Rotary Actuators, Specifications, Sizing and Selection of Pumps and Actuators.

UNIT IV:


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Control Valves

Construction, Working Principle, and Operation of Direction Control Valves, Flow Control Valves, and Pressure Control Valves, Including Check, Pressure Relief, Compound Pilot Operated Pressure Relief, Safety, Sequence, Pressure Reducing, Unloading, and Counterbalance Valves—Different Types of Center Positions of DCVs, Methods of Actuation of DCVs.

Hydraulic and Pneumatic Controllers used in Feedback Control systems

Construction, Working Principle, Operation of Proportional and Servo Control Valves, Including Servo-Type DCV-Like Nozzle Valves, Flapper-Type Valves, Mechanical Servo Valves, Single and Double Stage Servo Valves; Applications of Servomotor Systems In Feedback Control Systems.

UNIT V:**Hydraulic Circuits**

Reciprocation, Quick Return, Sequencing, Flow Control Circuits, Synchronizing Circuits, Accumulator Circuits, Industrial Circuits Such As Press Circuits, Machine Tool Circuits, Forklift, And Earth Mover Circuits - Design And Selection of Components.

Pneumatic Circuits

Compressed Air Production and Distribution, Pneumatic Control Components, Pneumatic Circuits:

Examples of Application.

TEXT BOOKS:

1. Industrial Hydraulics by John Pippenger and Tyler Hicks, McGraw Hill.
2. Oil Hydraulic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill.
3. Fluid Power with Applications by Anthony Esposito, Pearson.

REFERENCE BOOKS:

1. Fluid Power: Generation, Transmission and Control, Jagadeesha T., Thammaiah Gowda, Wiley.
2. The Analysis & Design of Pneumatic Systems by B. W. Anderson, John Wiley.
3. Control of Fluid Power Analysis and Design by Mc Clay Donaldson, Ellis Horwood Ltd.
4. Hydraulic and Pneumatic Controls: Understanding made Easy, K. Shanmuga Sundaram, S.Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009) Agrawal B. & Agrawal C.M. ,Engineering Graphics, TMH Publication

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Analyze the advantages, limitations, and applications of various power transmission systems in engineering practice.
2. Understand the system components and Hydraulic and Pneumatic symbols.
3. Select and size pumps and actuators appropriately for specific hydraulic system applications, considering load, speed, and efficiency requirements.
4. Analyze and apply control valve systems in hydraulic and pneumatic feedback control applications to achieve precise motion and pressure control.
5. Design and develop hydraulic and pneumatic circuits for different engineering applications.



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Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	2	2	1	1	1	–	–	–	1	2	3	2
CO2	3	2	2	2	2	–	–	–	–	–	–	2	3	3
CO3	3	3	3	2	2	1	–	–	–	–	1	2	3	2
CO4	3	3	3	2	3	1	–	–	–	–	1	2	2	1
CO5	3	3	3	3	3	1	1	–	–	2	2	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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POWER PLANT ENGINEERING

(PROFESSIONAL ELECTIVE -IV-1)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E21	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Provide fundamental knowledge of energy demand and supply scenarios, various types of power plants, and economic factors influencing power generation and selection of suitable plants.
2. Impart detailed understanding of the layout, operation, and design considerations of hydroelectric and steam power plants, including their components and site selection criteria.
3. Familiarize students with the working principles, components, and layouts of diesel and gas turbine power plants, and their integration in combined cycle operations.
4. Explain the principles of nuclear and non-conventional power generation systems, their components, working mechanisms, safety, and environmental aspects.
5. Develop an understanding of power plant economics, load characteristics, and environmental impacts of power generation, along with methods for pollution control and sustainability.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

Basic Concepts: Energy demand and supply scenario -Power plant layout and components - Factors affecting plant selection.

Classification of Power Plants: Steam (Thermal), Hydro, Nuclear, Diesel, Gas Turbine, Combined Cycle.

Power Plant Economics: Capital cost, operating cost- Fixed and variable costs -Tariffs and cost per unit generation.

UNIT II:**(L-12 + P-0 =12)**

Hydro-Electric Power Plants: Classifications, Components and their general layout, Hydroelectric survey, rainfall run-off, hydrograph, flow duration curve, mass curve, storage capacity, Site selection.

Steam Power Plant: Introduction, Developing trends, Essential features, Site Selection, Coal-its storage, preparation, handling, feeding and burning, Ash handling, dust collection, High pressure boilers.

UNIT III:**(L-12 + P-0 =12)**

Diesel and Gas Turbine Power Plants: Field of use, components, Plant layout, Comparison with steam power plants, Operation of combined steam and gas power plants.

UNIT IV:**(L-12 + P-0 =12)**

Nuclear Power Plants: Nuclear fuels, nuclear energy, Main components of nuclear power plant, Nuclear reactors-types and applications, Radiation shielding, Radioactive waste disposal, Safety aspects.

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Non-Conventional Power Generation: Geothermal power plants, Tidal power plants, Wind power plants, Solar power plants, Electricity from city refuse.

UNIT V:

(L-12 + P-0 =12)

Power Plant Economics and Environmental Considerations: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, Load curves, load duration curve. Definitions of connected load, Maximum demand, demand factor, average load, load factor, diversity factor – related exercises. Effluents from power plants and Impact on environment – pollutants and pollution standards – Methods of Pollution control.

TEXT BOOKS:

1. Arora S.C. & Domkundwar S.: A Course in Power Plant Engineering, Dhanpat Rai
2. Power Plant Engineering, P.K. Nag, Third edition Tata McGraw- Hill ,2007
3. G.D.Rai, “Introduction to Power Plant technology” Khanna Publishers, 1995
4. Power Plant Technology, M.M. El-Wakil, McGraw-Hill Education
5. Steam Turbine Theory and Practice, William J. Kearton, CBS Publication
6. Gas Turbines by V Ganeshan, McGraw Hill Education

REFERENCE BOOKS:

1. G.R,Nagpal , “Power Plant Engineering”, Khanna Publishers 1998
2. K.K.Ramalingam , “ Power Plant Engineering “, Scitech Publications, 2002
3. Combined Power Plants by J.H.Horlock Pergamon Press
4. Openshaw Taylor: Nuclear Power Plant, 1st Edition, Philosophical Library, 1960.
5. Skrotzki & Vopat: Power Station Engineering and Economy,
6. Gaffert: Steam Power Stations, 4th Edition, McGraw-Hill, 1952.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Classify various types of power plants, analyze their components, and evaluate their suitability based on energy demand, supply, and economic considerations.
2. Explain the layout, working, and design features of hydro and steam power plants, and assess site selection parameters for efficient operation.
3. Compare and contrast diesel, gas turbine, and combined cycle power plants, and evaluate their performance for different operating conditions.
4. Describe the functioning of nuclear and renewable energy-based power plants, emphasizing reactor types, safety measures, and waste disposal techniques.
5. Analyze power plant economics and environmental impacts, compute cost parameters, and propose pollution control strategies for sustainable power generation.



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Mapping of Course Outcomes with Program Outcomes:													
PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
3	2	1	-	-	-	-	-	-	1	2	2	2	1
3	2	2	2	1	-	1	-	1	2	2	2	2	1
3	3	2	2	2	1	1	-	1	1	2	3	2	1
3	2	1	2	1	1	3	2	1	1	2	2	2	1
3	3	2	3	2	2	3	2	1	2	3	3	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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REFRIGERATION AND AIR CONDITIONING**(PROFESSIONAL ELECTIVE -IV-2)****Credits: 3****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E22	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Provide fundamental knowledge of refrigeration cycles, principles, performance evaluation, and comparison of system efficiencies.
2. Develop understanding of refrigerants, their properties, environmental impact, and selection of alternative, eco-friendly refrigerants.
3. Explain the construction, operation, and performance characteristics of major refrigeration components such as compressors, condensers, evaporators, expansion devices, and cooling towers.
4. Impart knowledge of refrigeration controls, charging procedures, testing methods, and recent advancements, including cryogenics.
5. Introduce psychrometric principles, air-conditioning processes, and cooling load estimation using psychrometric charts.

COURSE CONTENT:

Unit-I

(L-12)

Refrigeration Cycles: Thermodynamic analysis of vapour compression, absorption, air cycle, steam jet and thermoelectric refrigeration systems. Comparison of COP and cost – Properties and selection of refrigerants – alternative refrigerants.

Unit-II

(L-12)

Component parts: Reciprocating compressors – Condensers – Air cooled and Water cooled – Economical water rate – Evaporators – Defrosting – Design of towers and evaporative condensers.

Unit-III

(L-12)

Refrigeration Control: Automatic and thermostatic expansion valve – Capillary tube – Compressor controls – miscellaneous controls. Testing and charging refrigeration units. Cryogenics – liquification and purification of gases. Applications of refrigeration – dry ice, walk-in-Cooler, Water Coolers, Transportation, Food processing & Preservation, refrigerators, recent developments in refrigeration.

Unit-IV

(L-12)

Air Conditioning: Basic Concepts : Fundamental functions of air conditioning – psychrometrics – air and humidity calculations – sensible heat factor – analysis of air conditioning process and cycles with psychrometric chart – Cooling load calculations.


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Unit-V
(L-12)

Comfort Air Conditioning: Physiological reactions to cooling – The effective temperature and its use in the determination of standards of comforts – comfort chart – comparison of domestic, industrial and commercial applications of air conditioning.

Ventilation system: Summer and winter ventilation – Ventilation of hot working spaces – industrial ventilation – air cleaning. Controls: Automatic control of air conditioning systems – Duct work selection of fans.

COURSE OUTCOMES: After successful completion of this course, the students will be able to

1. Explain the working principles and thermodynamic analysis of various refrigeration cycles, including vapour compression, absorption, air cycle, steam-jet, and thermoelectric systems.
2. Compare COP, cost effectiveness, environmental impact, and select suitable refrigerants based on properties and application needs.
3. Analyze the working and performance characteristics of refrigeration components such as reciprocating compressors, condensers, evaporators, cooling towers, and expansion devices.
4. Demonstrate knowledge of automatic controls, testing, charging procedures, and evaluate practical applications including cryogenic systems.
5. Apply psychrometric concepts and perform cooling load calculations for comfort and industrial air-conditioning systems.

Text Books:

1. R.S. Khurmi, J.K. Gupta, Refrigeration and Air Conditioning, Fifth Edition, S Chand Publishers, 2022.
2. R. K. Rajput, Refrigeration and Air-Conditioning, Reprint 2013 edition, S.K. Kataria & Sons
3. Roy J. Dossat, "Principles of Refrigeration", 4th edition, Pearson Education Asia, 2009.
4. Stoecker, W.F. and Jones J. W., Refrigeration and Air Conditioning, Second Edition McGraw Hill, New Delhi, 1986.

Reference Books:

1. Refrigeration and Air Conditioning, C P Arora, Third Edition, Tata McGraw-Hill Publishing Company Limited, 2009.
2. Ramesh Chandra Arora, Refrigeration and Air Conditioning, First Edition, PHI Learning Private Limited, 2010.
3. Refrigeration and Air Conditioning by Manohar Prasad, New Age International Publisher
4. Jones W.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, 2001


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CO- PO Mapping:

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	2	1	1	1	1	2	3	2
CO2	2	2	2	2	1	2	3	1	1	1	1	2	3	3
CO3	3	2	3	2	2	1	2	1	1	1	1	2	3	2
CO4	2	2	2	2	1	1	2	1	1	1	2	2	2	2
CO5	3	3	2	3	2	1	2	1	1	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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TIRUPATI-517 502

QUALITY CONTROL AND RELIABILITY ENGINEERING (PROFESSIONAL ELECTIVE -IV-3)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E23	ME

Pre-Requisites: None

This course covers the fundamentals of quality control, reliability concepts, and statistical methods for engineering applications. It includes inspection techniques, control charts, process capability, failure analysis, and reliability prediction. Emphasis is on ensuring product quality, minimizing defects, and improving system performance in industrial settings.

COURSE OBJECTIVES: The main learning objective of this course is

1. Able to study Inspection and quality control.
2. Able to study the process capability analysis.
3. Able to study the Acceptance sampling plans.
4. Able to study the concepts of Reliability.
5. Able to study the quality cost and quality circles.

COURSE CONTENT:**UNIT I: (L-10)**

Introduction to Inspection and Quality Control: Objectives of Statistical Quality Control, Chance and Assignable Causes of variation, Control chart basic principles, Choice of control limits, Sample frequency and rational subgroups. Control charts for variables: $\bar{X}$ and R chart and σ charts, Interpretation of control charts.

UNIT II: (L-10)

Process Capability Analysis: Specification limits and Control limits, Natural tolerance limits, Specifications and Process Capability, Process Capability indices, setting tolerances on assemblies and components. Control Charts for Attributes, P chart, C chart, U chart, Sensitivity analysis of P charts, Quality Rating System.

UNIT III: (L-8)

Acceptance Sampling Plans for Attributes: Types of Sampling Plans, Advantages and disadvantages of Sampling Plans, Evaluation of Sampling Plans – OC, Curve, Characteristics of OC Curve, Producer risk and Consumer risk, AOQ, AQL, ATI, ASN, LTPD. Multiple and Sequential sampling plans. Skip lot Sampling plan, Chain Sampling Plan.

UNIT IV: (L-10)

Reliability: Concepts of reliability, Scope, Importance of reliability, Failure data analysis: MTTF, MTBF, MTTR, Failure rate curve. **System Reliability:** Series, Parallel and Mixed configurations. **Reliability Improvement:** Active and Stand by redundancies, Introduction to Fault Tree Analysis, Maintainability and Availability.

UNIT V: (L-8)

Quality Costs: Prevention, Appraisal, Internal failure and External failure costs, Quality and Productivity, Total Quality Management, Quality function deployment, Tools for

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continuous quality improvement. **Quality Circles:** Concepts, Objectives and advantages. Introduction to Six Sigma Concept. Features of ISO 9000 quality system- Classification, Need, advantages and limitations.

TEXT BOOKS:

1. Douglas C. Montgomery –Introduction to Statistical quality control- John Wiley & sons, 8th Edition 2020
2. Gupta, R.C. Statistical Quality control, Khanna Publishers, 9th Edition, 2021.
3. Patrick D. T. O'Connor and Andre Kleyner - Practical Reliability Engineering, John Wiley & sons, 6th Edition, 2025
4. Ebeling C.-An Introduction to Reliability and Maintainability Engineering – Tata Mc Graw hill publishing company Ltd., 3rd Edition, 2019.

REFERENCE BOOKS:

1. Basterfield D.H., Quality Control, A Practical Approach, Prentice Hall, 1st Edition 1993.
2. Grant E.L. Statistical Quality Control McGraw-Hill, 7th edition, 1996.
3. L.S. Srinath, Reliability Engineering, Affiliated East west press Pvt.Ltd. 4th Edition, 2005.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Students able to analyse the basic techniques of quality improvement fundamental knowledge of statics and probability.
2. Students able to visualize the use control charts for improving the process quality.
3. Students able to understand the different sampling plans.
4. Students able to understand the concepts of Reliability
5. Students able to analyse the quality cost and quality circles.

Mapping of Course Outcomes with Program Outcomes:

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

1 - Slightly; 2 - Moderately; 3 – Substantially



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ENERGY MANAGEMENT AND AUDIT

(PROFESSIONAL ELECTIVE -IV-4)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E24	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Provide knowledge of the current energy scenario and the importance of energy conservation and management.
2. Explain the principles, types, and methodologies of energy audits for identifying and evaluating energy-saving opportunities.
3. Develop understanding of energy management systems, programs, and the role of energy managers and auditors.
4. Familiarize students with energy efficiency measures in thermal and electrical systems, including waste heat recovery and cogeneration.
5. Introduce tools, techniques, and technologies for improving overall energy performance and sustainability in industries and buildings.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)****General Aspects of Energy Scenario**

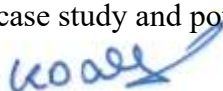
Review of energy scenario in India, General Philosophy and need of Energy Audit and Management, Basic elements and measurements Mass and energy balances Scope of energy auditing industries - Evaluation of energy conserving opportunities, Energy performance contracts, Fuel and Energy substitution, Need for Energy Policy for Industries, National & State level energy Policies.

UNIT II:**(L-12 + P-0 =12)****Energy Audit Concepts**

-Need of Energy audit Types of energy audit Energy management (audit) approach understanding energy costs Bench marking Energy performance Matching energy use to requirement - Maximizing system efficiencies -Optimizing the input energy requirements - Duties and responsibilities of energy auditors- Energy audit instruments - Procedures and Techniques.

UNIT III:**(L-12 + P-0 =12)****Principles and Objectives of Energy Management**

Design of Energy Management Programmes Development of energy management systems Importance Indian need of Energy Management Duties of Energy Manager Preparation and presentation of energy audit reports Monitoring and targeting, some case study and potential energy savings.


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UNIT IV:**(L-12 + P-0 =12)****Thermal Energy Management**

Energy conservation in boilers - steam turbines and industrial heating systems - Application of FBC Cogeneration and waste heat recovery-Thermal insulation Heat exchangers and heat pumps -HVC industries-Building Energy Management.

UNIT V:**(L-12 + P-0 =12)****Electrical Energy Management**

Supply side Methods to minimize supply-demand gap- Renovation and modernization of power plants - Reactive power management - HVDC- FACTS - Demand side - Conservation in motors -Pumps and fan systems - Energy efficient motors.

TEXT BOOKS:

1. Murphy, W. R., Energy Management, Elsevier, 2007.
2. Smith, C. B., Energy Management Principles, Pergamum, 2007
3. Handbook of Energy Audit, Sonal Desai, McGraw Hill Education Private Ltd.,

REFERENCE BOOKS:

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Energy Management Handbook W.C. Turner (John Wiley and Sons, A Wiley Interscience publication)
4. Industrial Energy Management and Utilization -L.C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington, 1988)
5. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
6. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice hall1993)

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Analyze the present energy scenario and understand the need for energy auditing, management, and policy formulation.
2. Apply various methods and techniques of energy auditing to identify and evaluate energy conservation opportunities in industries.
3. Design and implement energy management programs, and effectively perform the duties of an energy manager or auditor.
4. Evaluate energy conservation techniques in thermal systems such as boilers, turbines, heat exchangers, and HVAC systems
5. Examine methods of electrical energy management including power factor improvement, efficient motor systems, and demand-side management.


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Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO2
CO1	3	2	1	1	1	2	3	1	1	1	1	2	2	2
CO2	3	2	2	2	2	1	3	1	1	2	1	1	2	2
CO3	3	2	2	2	1	1	3	1	1	2	2	2	2	2
CO4	3	2	2	2	1	1	3	1	2	2	2	1	2	2
CO5	3	2	2	2	2	1	2	1	1	2	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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ALTERNATE FUELS
(PROFESSIONAL ELECTIVE -IV-5)

Credits: 3**Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E25	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. To understand the need for alternative fuels in view of depleting petroleum resources, environmental concerns, and sustainable energy development.
2. To study the availability, properties, and ASTM standards of alcohol-based fuels; and to analyze their suitability, performance, and emission characteristics in spark ignition engines.
3. To explore the use of vegetable oils such as soybean, jatropha, pongamia, rice bran, and mahua as alternative fuels and to understand the process of esterification for biodiesel production.
4. To examine the properties, availability, and application of gaseous fuels such as CNG and LPG, including necessary engine modifications and their impact on performance and emissions in SI and CI engines.
5. To understand hydrogen production methods, hydrogen as an alternative fuel, the working of fuel cells, and vehicle emission standards including EURO and Indian norms for evaluating cleaner technologies.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)****Introduction to Alternate Fuels:**

Need for alternate fuels – Desirable characteristics of a good alternate fuel – Properties of air, Combustion with air – Equivalence ratio – Enthalpy of formation – Adiabatic combustion temperature – Dissociation phenomena.

UNIT II:**(L-12+ P-0 =12)****Alcohols as Engine Fuels:**

Estimation of petroleum reserves – Need for alternate fuels – Availability and properties of alternate fuels – ASTM standards – General use of alcohols – Properties as engine fuels – Gasoline and alcohol blends – Performance in SI engines – Methanol and gasoline blends – Combustion and emission characteristics.

UNIT III:**(L-12 + P-0 =12)****Vegetable Oils and Biodiesel Fuels:**

Vegetable oils such as Soybean oil, Jatropha, Pongamia, Rice bran oil, Mahua, etc., as

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alternate fuels – Physical and chemical properties – Process of esterification – Production of biodiesel – Performance and emission characteristics in IC engines.

UNIT IV: (L-12 + P-0 =12)

Gaseous Fuels (CNG and LPG):

Availability and properties of Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) – Engine modifications required for CNG/LPG operation – Performance, combustion, and emission characteristics in SI and CI engines.

UNIT V: (L-12 + P-0 =12)

Hydrogen and Fuel Cell Technologies:

Hydrogen production methods – Storage and handling of hydrogen – Hydrogen as an alternative fuel – Principles and operation of fuel cells – Evaluation of vehicle emissions – EURO and Indian emission standards.

COURSE OUTCOMES: Upon successful completion of the course, the student will be a

1. Understand the need and importance of alternate fuels in reducing dependence on petroleum resources.
2. Study the properties and combustion characteristics of various alternate fuels.
3. Explore methods of production and utilization of biodiesel, alcohols, gaseous fuels, and hydrogen.
4. Analyze engine performance and emission characteristics when operated with different alternate fuels.
5. Familiarize with international and Indian vehicle emission standards

TEXT BOOKS:

1. L. Richard, P.E. Bechhold, Alternate Fuels Guide Book, Society of Automotive Engineers, 1997
2. Norbeck, M. Joseph, Hydrogen fuel for surface transportation, Society of Automotive Engineers, 1996
3. S.C. Bhatia, Air Pollution and its Control, Atlantic Publications, 2007

REFERENCE BOOKS:

1. Anil Agarwal, Sunita Narain, Global Warming in an unequal world, Centre for Science and Environment, New Delhi, 2003
2. Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka, Handbook of Alternate Fuels Technology, CRC Press, 2007


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Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO2
CO1	3	2	1	1	2	1	2	1	1	1	1	2	2	1
CO2	3	3	2	2	3	2	1	1	2	2	1	2	3	2
CO3	3	2	2	3	3	2	2	1	1	1	1	2	3	3
CO4	3	2	3	3	3	2	2	2	2	2	1	3	3	3
CO5	2	2	1	2	2	3	3	3	2	2	3	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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DATA SCIENCE FOR MECHANICAL ENGINEERS**(PROFESSIONAL ELECTIVE -IV-6)****Credits: 3****Assessment: 40 +60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-5-6-R25E26	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To introduce the basic concepts and process of data science.
2. To understand descriptive statistical methods and data visualization techniques.
3. To learn the fundamentals of probability, distributions, and hypothesis testing.
4. To understand data preprocessing and data management techniques.
5. To introduce basic predictive analytics and machine learning concepts.

COURSE CONTENT:**UNIT I: (L-10)**

Overview of Data Science: Data Science Process, Problem Definition, Data Collection, Data Preparation (cleaning and transformation), Exploratory data Analysis, Model Building, Model Evaluation and Model Deployment

UNIT II: (L-10)

Descriptive Statistics: Measures of Central Tendency (Mean, Median and Mode) and spread and position (range, Variance, Standard Deviation and quartile), Data Visualization.

UNIT III: (L-10)

Inferential Statistics: Probability theory, Data Distributions (Binomial, Poisson, Geometric, Exponential, Sampling and Normal), Hypothesis Testing

UNIT IV: (L-10)

Data management: Data preprocessing (Data cleaning and aggregation), Data retrieval and transformation, Binary Encoding One-Hot Encoding, Standardization and Normalization



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UNIT V:**(L- 10)**

Predictive Analytics: Concept of machine learning algorithms, Supervised and unsupervised algorithms, Introduction to reinforcement algorithms.

TEXT BOOKS:

1. J. Grus, Data Science from Scratch, O'Reilly Media, Inc. 2nd Edition, 2019
2. Thomas Nield, Essential Math for Data Science, O'Reilly Media, June 2022.
3. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning, Springer, 2021.

REFERENCE BOOKS:

1. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016.
2. L. Igual and S. Seguí, Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications, 1/e, Springer, 2017 (ISBN978-3-319-50016-4).

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand and explain the data science workflow from problem definition to model deployment.
2. Apply descriptive statistical measures and visualization techniques to analyze data.
3. Use basic probability concepts and hypothesis testing for data analysis.
4. Perform data preprocessing techniques such as cleaning, encoding, and normalization.
5. Apply basic machine learning concepts for predictive analytics.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	1	–	–	–	–	–	–	1	2	1
CO2	3	2	1	2	2	–	–	–	–	–	–	1	2	1
CO3	3	3	1	2	1	–	–	–	–	–	–	1	2	1
CO4	2	2	1	2	3	–	–	–	–	–	–	2	2	1
CO5	3	3	2	2	3	–	–	–	–	–	–	2	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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INTRODUCTION TO SEMICONDUCTOR MANUFACTURING (PROFESSIONAL ELECTIVE -IV-7)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code (7-0-1-01R25)	Branches
VI	3-0-0	7-0-6-R25CE1	CH,CE,EE,EC,ME,CS (All Branches)

Course Overview:

This course deals with semiconductor materials, semiconductor wafer manufacturing and characterization, semiconductor device manufacturing techniques, characterization and advanced processing tools, semiconductor ecosystem and applications.

This course prepares the students to apply their knowledge for designing the processes and manufacturing the equipment and tools for semiconductor device manufacturing in India under the National Semiconductor Mission Programme.

Course Objective(s):

- To explain the physics of semiconductor materials and devices.
- To discuss the processes involved in semiconductor manufacturing.
- To understand the ecosystem of semiconductor manufacturing.
- To get knowledge of safety aspects in the semiconductor industry.
- To design systems and equipment for semiconductor manufacturing.

UNIT – 1:

Semiconductor materials (Si, Ge, GaAs, GaN, SiC):

Electrical classification of solids (metals, semiconductors and insulators), intrinsic and extrinsic semiconductors, crystal structure and defects, band gap and Fermi level, doping effects on electrical conduction in semiconductors, direct and indirect bandgap semiconductors.

UNIT – 2:

Semiconductor wafer manufacturing and characterization:

Thermal and chemical processes involved in converting pure sand into electronic grade polycrystalline silicon, pure silicon crystal growth from polysilicon, silicon wafer fabrication and polishing.



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UNIT – 3:**Thin film fabrication and characterization:**

Vacuum-based thin film deposition techniques for metals, semiconductors and dielectrics; Physical Vapour Deposition (PVD); Chemical Vapour Deposition (CVD); analytical characterization techniques (XRD, SEM, TEM, XPS etc.); plasma, lasers and ion beams for semiconductor manufacturing.

UNIT – 4:**Semiconductor Device Manufacturing Techniques:**

Introduction to IC-chip manufacturing, oxidation, lithography, etching, doping, diffusion, ion-implantation and metallization, realization of on-chip resistor, diode, capacitor and inductor, bonding and packaging.

UNIT – 5:**Semiconductor ecosystem, safety and applications:**

Clean room aspects, gas handling systems in semiconductor manufacturing, safety aspects in device fabrication (electrical, chemical and vacuum), clean water and pure chemical requirements, CMOS-based IC chips for computers and mobiles, semiconductor-based solar cells and displays, lab-grown diamonds for semiconductor applications.

Textbooks:

1. Sze SM and Lee MK, *Semiconductor Devices: Physics and Technology*, 3rd Edition, Wiley India (2016).
2. Swami Nathan P, *Semiconductor Materials, Devices and Fabrication*, Wiley (2019)

References:

1. Neaman D, *Semiconductor Physics and Devices*, 4th Edition, McGraw Hill (2017).
2. MKS Handbook: *Semiconductor Devices and Process Technology*, 2nd Edition (2017).
3. Gandhi S.K, *VLSI Fabrication Principles: Silicon and Ga-As*, 2nd Edition, Wiley (2008).


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Course Outcomes: **After completing this course, students will be able to**

1. Understand the basic properties and behavior of semiconductor materials used in electronic devices.
2. Learn how semiconductor wafers are manufactured from raw materials to finished silicon wafers.
3. Gain knowledge of thin-film deposition methods and basic material characterization techniques.
4. Understand the main steps involved in semiconductor device and IC fabrication processes.
5. Become familiar with the semiconductor manufacturing ecosystem, safety practices, and major applications of semiconductor devices.

Mapping of course outcomes with program outcomes:

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


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**B. Tech. (Mechanical Engineering)
VII (Fourth Year)**

Code		Category	Course Title	Hours/Week			Total	Credits	Marks		
Department	University			L	T	P			CIE	SEE	Total
ME 5701C	7-5-7-01R25	ME-PC	Industrial Engineering and Management	3	0	0	3	3	40	60	100
ME 5702C	7-5-7-02R25	ME-PC	Automobile Engineering	3	0	0	3	3	40	60	100
ME 5703E	7-5-7-R25E1	ME-PE	Professional Elective- V	3	0	0	3	3	40	60	100
ME 5704E	7-5-7-R25E2	ME-PE	Professional Elective -VI	3	0	0	3	3	40	60	100
ME 5705O	7-5-7-R25O1	ME-OE	Open Elective- II (MOOCS)	0	0	0	0	3	0	100	100
ME 5706O	7-5-7-R25O2	ME-OE	Open Elective- III (MOOCS)	0	0	0	0	3	0	100	100
ME 5707S	7-5-7-R25S1	ME-SC	Robotics Lab	1	0	2	3	0	40	60	100
ME 5708I	7-0-7R25CS	ME-SI	Summer Industrial Internship	0	0	0	0	2	100	0	100
				13	0	2	15	20.0	300	500	800



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MECHANICAL ENGINEERING

PROFESSIONAL ELECTIVE COURSES

Professional Elective - I (V Sem)	7-5-5-R25E11	Non-conventional Energy Sources
	7-5-5-R25E12	Welding Technology
	7-5-5-R25E13	Mechanical Vibrations
	7-5-5-R25E14	Product Design and Development
	7-5-5-R25E15	Biomedical Engineering
	7-5-5-R25E16	Geometric Modelling for CAD
Professional Elective – II (V Sem)	7-5-5-R25E21	Advanced Manufacturing Processes
	7-5-5-R25E22	Composite Materials
	7-5-5-R25E23	Design for Manufacturing and Assembly
	7-5-5-R25E24	Value Engineering
	7-5-5-R25E25	Fuel Cell Technology
	7-5-5-R25E26	Robotics
Professional Elective – III (VI Sem)	7-5-6-R25E11	Analysis and Control of Production Systems
	7-5-6-R25E12	Introduction to Drone Technology
	7-5-6-R25E13	Industrial Safety
	7-5-6-R25E14	Introduction to Turbo Machinery
	7-5-6-R25E15	Tool Design
	7-5-6-R25E16	Oil Hydraulics and Pneumatics
Professional Elective – IV (VI Sem)	7-5-6-R25E21	Power Plant Engineering
	7-5-6-R25E22	Refrigeration and Air-conditioning
	7-5-6-R25E23	Quality control and Reliability Engineering
	7-5-6-R25E24	Energy Management and Audit
	7-5-6-R25E25	Alternative fuels
	7-5-6-R25E26	Data Science for Mechanical Engineers
	7-0-6-R25CE1	Introduction to Semiconductor Manufacturing
Professional Elective – V (VII Sem)	7-5-7-R25E11	Additive Manufacturing
	7-5-7-R25E12	Mechatronics
	7-5-7-R25E13	Supply Chain Management
	7-5-7-R25E14	Maintenance Engineering and Management
	7-5-7-R25E15	Finite Element Method
	7-5-7-R25E16	Tribology
Professional Elective – VI (VII Sem)	7-5-7-R25E21	Project Management
	7-5-7-R25E22	Hybrid Electric Vehicles
	7-5-7-R25E23	Flexible Manufacturing Systems
	7-5-7-R25E24	Design and Analysis of Experiment
	7-5-7-R25E25	Artificial Intelligence and Machine Learning
	7-5-7-R25E26	Lean Manufacturing and Six Sigma



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INDUSTRIAL ENGINEERING AND MANAGEMENT**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-01R25	ME

Pre-Requisites: None.**COURSE OBJECTIVES:** The main learning objective of this course is

1. To know the role of industrial engineer and, to understand and apply the concepts of sales forecasting, PPC .
2. To understand the concepts of plant location, layout, material handling
3. To apply the concepts of workstudy, job evaluation, merit rating, quality control
4. To understand the emerging concepts of Industrial Engineering for different applications.
5. TO understand the concepts of management and Industrial acts

COURSE CONTENT:**UNIT I:****INDUSTRIAL ENGINEERING:** Definition, functions of industrial engineer, definition of productivity.**SALES FORECASTING:** Need, Classification of forecasting methods, Moving average, exponential smoothing and linear regression techniques.**PRODUCTION PLANNING AND CONTROL:** Objectives and functions of PPC, Types of production systems**UNIT II:****PLANT LOCATION AND LAYOUT:** Location factors. Choice of city, Suburban and country locations. Plant Layout – Definition, Objectives, Salient features of product, process and fixed position layouts. **MATERIAL HANDLING:** Definition, Objectives, Classification of material handling equipment and factors influencing their selections**UNIT III:****WORK STUDY:** Definition, objectives, Method study – definition. Objectives procedure and uses. Time Study : Definition, need, Time Study procedure, Calculation of standard time.**JOB EVALUATION AND MERIT RATING:** Need and procedure**QUALITY CONTROL:** Definition and control charts-X,R,P charts (simple problems)


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UNIT IV:**CONTEMPORARY PRACTICES:**

Basic concepts of Just-In-Time (JIT) System, value analysis, Materials Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II), Enterprise Resource Planning (ERP), lean tools, lean six sigma, Kaizen.

UNIT V:**MANAGEMENT CONCEPTS**

Administration, Management and Organization. Functions of Management. Fayol's Principles of Management. Types of Organization. Taylor's Scientific Management. Functions of personnel management

INDUSTRIAL ACTS: Factories Act, Industrial disputes Act and Workmen's Compensation Act.

TEXT BOOKS:

1. Khanna O P: Industrial Engineering and Management, 7th Edition, Dhanpat Rai & Sons, 2002
2. Panner Selvam R, Production and Operation Management
3. Industrial Engineering and Production Management by Mahajan Dhan, 5th Edition, Dhanpat Rai & Co, 2011

REFERENCE BOOKS:

1. Adam & Edbert: Production/Operation Management, 5th Edition, Prentice Hall, 1992
2. Joseph G Monks: Operation Management, 3rd Edition, McGraw-Hill, 1987
3. Buffa E S: Modern Production/Operation Management, 8th Edition, Wiley India, 2007
4. Clade S. George Jr : Management for Business Industry, 1972
5. Ralph Barnes: Principles Of Motion and Time Study, Tata McGraw Hill, 1956

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand the role of an industrial engineer and apply the concepts of sales forecasting and PPC.
2. Analyze the concepts of plant location, layout, and material handling.
3. Apply the concepts of work study, job evaluation, merit rating, and quality control.
4. Evaluate the emerging concepts of Industrial Engineering for different applications.
5. Explain the concepts of management and the principles of Industrial Acts.


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MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	2	2	3	2	2	3	2	3	3	2	2
CO2	3	3	3	2	2	2	2	2	2	2	2	3	2	2
CO3	3	2	2	3	1	1	1	2	2	2	1	3	2	2
CO4	2	2	3	3	3	1	1	1	3	3	2	3	3	3
CO5	2	2	2	3	3	1	1	2	2	2	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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AUTOMOBILE ENGINEERING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-02R25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is to prepare the students to

1. **Understand the basic layout and structure of an automobile**, including the chassis, body, power transmission system, and various types of engines and forced induction methods such as turbocharging and supercharging.
2. **Explain the operation of fuel supply systems** in both spark ignition (S.I.) and compression ignition (C.I.) engines, including carburetors, fuel injection systems, and pollution control technologies in line with national and international emission norms.
3. **Describe cooling and ignition systems**, including air and liquid cooling methods, radiators, thermostats, battery and magneto ignition systems, and associated components and understand automotive electrical systems, including charging, lighting, instrumentation, and modern features such as remote locking, hybrid, and electric vehicle systems.
4. **Analyze various transmission components**, including different types of clutches, gearboxes, torque converters, and propeller shafts, and explain their functions and construction.
5. **Explain the suspension, braking, and steering systems** of vehicles, including mechanical and hydraulic brakes, shock absorbers, steering geometry (Ackerman and Davis), and power steering mechanisms.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

Introduction - Layout of automobile, Chassis and body – power transmission –types of engines, engine construction, turbo charging and super charging – **Lubrication System:** engine lubrication, splash and pressure lubrication systems, **Linners-** dry and Wet type, function and constructional details, **Mufflers and Types:** Baffle type muffler, Wave cancellation type muffler, **Types of tyres** and Alignment test.

UNIT II:**(L-12+ P-0 =12)****Fuel Supply System:**

S.I. Engine: Fuel supply systems, Mechanical and electrical fuel pump, **Carburettor:** types, **Air cleaners and types** – Light duty, Heavy duty. **C.I. Engines:** Requirements of diesel injection systems, types of injection systems, fuel pump. **Emission from Automobiles:** Pollution standards National and international (BS & ES) – Pollution Control, Techniques, Multipoint fuel injection system, Common rail diesel injection system, Gasoline direct injection system, Ad Blue concept.

UNIT III:**(L-12 + P-0 =12)**

Cooling System: Cooling Requirements, Air Cooling, Liquid Cooling, Thermo, water and Forced Circulation System, **Radiators:** Types, Cooling Fan, water pump, thermostat, antifreeze solutions.

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Ignition System: Function of an ignition system, battery ignition system, constructional features of storage, battery, condenser and spark plug – Magneto coil ignition system,

Electrical System: Charging circuit, generator, starting system, lighting systems, Horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator, remote locking system and the electric and hybrid vehicles.

UNIT IV:

(L-12 + P-0 =12)

Transmission Systems:

Clutch: Function of clutch, single plate and multiple plate, and centrifugal clutches and clutch materials, fluid coupling, torque converter. **Gear box:** Need, sliding type, constant and synchromesh type. Automatic transmission. Propeller shaft; need and constructional details.

UNIT V:

(L-12 + P-0 =12)

Suspension System: Objects of suspension, Basic requirements, Air suspension and its features, Independent suspension, spring Shock absorbers-function, construction and working principle.

Braking System: Requirement of brake, Classification of brakes, Mechanical, Hydraulic, Pneumatic, brakes. Disc brakes and drum brake.

Steering System: Steering mechanism, Power Steering System, Electric steering mechanism.

Safety Systems: Introduction to antilock braking system (ABS) , Recent trends in Automobiles Electronic Control module (ECM) and Air bag systems.

TEXT BOOKS:

1. Automobile Engineering, Kirpal Singh Vol I & II, Standard publishers Distributors, Delhi
2. Automobile Engineering, R. K. Rajput, Laxmi Publication
3. Automobile Engineering : Narang G.B.S.
4. Internal Combustion Engines : V. Ganesan

REFERENCE BOOKS:

1. Automotive Mechanics : Heitner J.
2. Fundamentals of Motor Vehicle Technology : Hillier & Pittuck
3. I.C.Engines : Mathur M.L. & Singh R.P
4. High Speed Combustion Engines : Heldt P.M.
5. Automotive Mechanics Services : Course W.H.
6. Motor Manuals Vol. I to VII : Judge A.W.
7. Electric and hybrid vehicles. : Iqbal Husain, Boca Raton
London New York Washington, D.C., CRC PRESS



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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand and explain the basic layout of an automobile and the working of various engine types and lubrication systems.
2. Analyze different fuel supply systems for SI and CI engines and interpret the significance of emission standards and control technologies.
3. Describe the functioning of cooling, ignition, and electrical systems in automobiles, including the basics of hybrid and electric vehicles.
4. Demonstrate knowledge of various transmission systems, including clutches, gearboxes, torque converters, and propeller shafts.
5. Understand the working principles of suspension, braking, and steering systems and apply this knowledge in vehicle maintenance and design.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	2	1	3	1	3
CO2	3	3	2	2	1	2	2	1	1	2	1	3	1	3
CO3	3	2	2	1	2	1	2	1	1	2	1	3	1	3
CO4	3	2	2	1	1	1	1	1	1	2	1	3	1	3
CO5	3	3	3	2	2	1	1	1	1	2	1	3	1	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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ROBOTICS LAB**Credits: 0****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	1-0-2	7-5-7-R25S1	ME

Pre-Requisites: Before performing these experiments, students should have a basic understanding of industrial robots, including robot components, end-effectors, and control systems. Knowledge of work cell setup, creating frames, and robot commands (PUT, ATTACH, etc.) is essential. Students should also understand loading/unloading operations, handling components, and programming sequences, as well as basic safety practices in robotic work cells.

COURSE OBJECTIVES: The main learning objective of this course is

1. To understand the fundamental principles and components of industrial robots, including manipulators, end-effectors, and workcells.
2. To develop proficiency in robot programming using commands like PICK, PLACE, PUT, and ATTACH for various automation tasks.
3. To teach students how to create and manage frames, coordinate systems, and workcell layouts for precise robot operations.
4. To program robots for common industrial tasks, including pick-and-place, palletizing, loading/unloading, assembly, and sequential operations.
5. To enable students to position objects using multiple methods (absolute, relative, and frame-based) for enhanced flexibility.
6. To ensure safe operation of robots in a workcell by applying safety standards, emergency stops, and restricted zones

Course Content:

Robot and automation covering Pick-and-place, Work cell setup, Frame creation, Loading/unloading, Sequencing operations, Sensor and vision integration and Safety in robotic work cells.

Exercise 1: PICK AND PLACE ACTIVITY**Exercise 2:** TEACHING A ROBOT TO LOADING A CELL AND CHANGING PROJECTS**Exercise 3:** GETTING COMPONENTS INTO A CELL**Exercise 4:** TEACHING A ROBOT TO CREATING FRAMES IN TO THE WORK CELL**Exercise 5:** PROGRAMMING A ROBOT IN A WORK CELL BY USING PUT COMMAND**Exercise 6:** TEACHING A ROBOT TO CREATING FRAMES IN TO THE WORK CELL**Exercise 7:** TEACHING A ROBOT TO ATTACH COMMAND IN A WORK CELL**Exercise 8:** PROGRAMMING A ROBOT TO PERFORM PLAYING A SEQUENCE OF OPERATIONS

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Exercise 9: PROGRAMMING A ROBOT IN THREE WAYS TO POSITION AN INSTANCE**TEXT BOOKS:**

1. Industrial Robotics Technology Programming And Applications 2Ed (Sie) (Pb 2017) - by Nicholas Odrey (Author), Mitchell Weiss (Author), Mikell Groover (Author), Roger Nagel (Author)
2. Industrial Robots Programming: Building Applications for the Factories of the Future- J. Norberto Pires (Author)
3. Industrial Automation and Robotics - A.K. Gupta (Author), S.K. Arora (Author), J. Riescher Westcott (Author)

REFERENCE BOOKS:

1. **Industrial Robots Programming** — J. Norberto Pires. Focused on industrial robot programming, interfacing with PLCs, sensors, and automation systems.
2. **Fundamentals of Industrial Robots** — Newer textbook by Control.com, freely available, covering modern industrial robot fundamentals..
3. **Robotics and Control** — R.K. Mittal & I.J. Nagrath. A textbook used in many robotics curricula.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to

1. Apply knowledge of industrial robot components, workcell setup, and safety standards to basic robotic operations.
2. Program robots to execute pick-and-place, loading/unloading, and palletizing tasks in a workcell environment.
3. Develop robot programs using commands such as PUT, ATTACH, and sequence to automate industrial tasks.
4. Design and create coordinate frames and workcell layouts to enable accurate robot positioning.
5. Integrate sensors and vision systems into robot programs for object detection, tracking, and handling.

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	1	1	1	2	1	1	1	1	1	1	3	2
CO2	3	3	2	2	1	2	1	2	1	1	1	1	3	2
CO3	3	2	3	2	1	2	2	1	1	1	1	1	3	2
CO4	2	2	3	3	2	2	1	1	1	1	1	1	3	2
CO5	3	3	2	2	2	2	2	2	1	1	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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ADDITIVE MANUFACTURING
(PROFESSIONAL ELECTIVE -V-1)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E11	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Introduce the fundamental principles, terminology, evolution, and standards of Additive Manufacturing (AM).
2. Familiarize students with various AM systems, energy sources, and equipment characteristics, including design considerations for AM.
3. Provide comprehensive knowledge of different AM processes and hybrid manufacturing techniques.
4. Develop an understanding of materials used in AM, process-material selection guidelines, and pre- and post-processing techniques.
5. Expose students to AM software tools and real-world applications of AM in diverse engineering domains.

COURSE CONTENT:**UNIT I:****(L-10)**

Introduction: Basic Principles of Additive Manufacturing (AM), AM Parts, Generic AM Process, Use of term AM, Benefits of AM, Distinction Between AM and Conventional Manufacturing Processes, Examples of AM Parts, Classification of AM Processes, Heat Sources- Lasers, Electron Beam, Electric Arc/Plasma Arc. Milestones in AM Development, AM around the World and AM Standards.

UNIT II:**(L-10)**

AM Systems: Photopolymer-Based Systems, Powder-Based Systems, Molten Material Systems, Solid Sheets. Metal Systems - Use of Substrates, Energy Density, Weight, Accuracy, Speed, Build Rate. Maintenance of Equipment, Materials Handling Issues, Design for AM.

UNIT III:**(L-10)**

Additive Manufacturing Processes: Photopolymerization, Powder Bed Fusion Material Extrusion, Material Jetting, Sheet Lamination, Directed Energy Deposition Direct- Write technologies, Hybrid Additive Manufacturing.



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UNIT IV:**(L-10)**

Materials for Additive Manufacturing: Introduction, Liquid-Based Material, Support Material, Powder-Based Materials-Polymer Powder Material, Metal Powder Material, Ceramic Powder Material, Composite Powder for AM Processes, Solid-Based Materials, Material issues in AM. Guidelines for Process Selection, Challenges of Selection, Pre-Processing, Part Build Time, Post-Processing to Improve Surface Quality, Dimensional Deviations, Improve Mechanical Properties, Rapid Tooling.

UNIT V:**(L-10)**

AM Software: AM Software for STL Editing, Slicing, STL Manipulation, Process Visualization and Collision, Modeling and Simulation, Manufacturing Execution System Software for AM. **Applications:** Application Areas for AM-Enabled Product Development, Medical Modeling, Reverse Engineering Data, Architectural Modeling, Automotive, Aerospace.

TEXT BOOKS:

1. Gibson Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, “Additive Manufacturing Technologies”, Springer, 2021.

REFERENCE BOOKS:

1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017
3. Design for Advanced Manufacturing: Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.



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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain the fundamental principles, classifications, historical development, energy sources, and standards of Additive Manufacturing.
2. Compare and analyze different Additive Manufacturing systems and equipment characteristics with respect to accuracy, build rate, materials handling, and design for AM.
3. Differentiate and evaluate Additive Manufacturing processes, including photopolymerization, powder-based, extrusion, hybrid, and direct-write technologies.
4. Select and justify appropriate materials, AM processes, and post-processing techniques to achieve desired surface quality, dimensional accuracy, and mechanical properties.
5. Apply AM software tools and demonstrate the suitability of Additive Manufacturing for product development and industrial applications.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	1	–	–	–	–	–	–	–	1	–	1	3	1
CO2	3	3	2	1	2	–	–	–	–	1	–	1	3	1
CO3	3	3	3	2	2	–	–	–	–	1	–	1	3	1
CO4	3	3	3	2	2	–	2	–	–	1	–	1	3	1
CO5	2	2	2	–	3	2	2	–	1	1	–	2	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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MECHATRONICS

(PROFESSIONAL ELECTIVE -V-2)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E12	ME

Pre-Requisites: Basic Mechanical Engineering, Basic Electrical and Electronics Engineering

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Understand control, signal conditioning, and applications in automated systems.
2. Apply actuation, transmission, and precision components for advanced mechanical systems.
3. Design and implement safe, efficient electronic interfaces for sensors and actuators.
4. Develop skills in microcontroller and PLC interfacing, programming, and applications
5. Understand sensors, control systems, and implement multi-axis motion control applications.

COURSE CONTENT: Overview of The Course, History of Mechatronics, Scope And Significance of Mechatronics Systems, Elements of Mechatronic Systems, Needs And Benefits of Mechatronics In Manufacturing.

UNIT I:

Introduction:

Control Methods: Standalone, PC Based (Real Time Operating Systems, Graphical User Interface, Simulation) - Applications: SPM, Robot, CNC, FMS, CIM.

Signal Conditioning: Introduction – Hardware - Digital I/O, Analog Input – ADC, Resolution, Sped Channels Filtering Noise Using Passive Components – Resistors, Capacitors - Amplifying Signals Using OP Amps – Software - Digital Signal Processing – Low Pass, High Pass, Notch Filtering.

UNIT II:

Precision Mechanical Systems: Pneumatic Actuation Systems - Electropneumatic Actuation Systems - Hydraulic Actuation Systems - Electrohydraulic Actuation Systems - Timing Belts – Ball Screw And Nut - Linear Motion Guides - Linear Bearings - Harmonic Transmission – Bearings-Motor /Drive Selection

UNIT III:

Electronic Interface Subsystems: TTL, CMOS interfacing - Sensor interfacing – Actuator Interfacing-Solenoids, Motors Isolation Schemes- Opto Coupling, Buffer IC's - Protection Schemes – Circuit Breakers, Over Current Sensing, Resettable Fuses, Thermal Dissipation - Power Supply – Bipolar Transistors / MOSFETs.


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UNIT IV:

Microcontrollers Overview: Microcontroller, Micro-Processor Structure – Digital Interfacing - Analog Interfacing - Digital To Analog Convertors - Analog To Digital Convertors–Applications. Programming–Assembly, C (LED Blinking, Voltage Measurement By ADC).

Programmable Logic Controllers: Basic Structure - Programming: Ladder Diagram - Timers, Internal Relays And Counters - Shift Registers - Master And Jump Controls - Data Handling - Analog Input / Output - PLC Selection - Application.

UNIT V:

Devices: Position , Velocity Sensors - Optical Incremental Encoders - Proximity Sensors: Inductive , Capacitive, Infrared-Continuous And Discrete Processes - Control System Performance & Tuning - Digital Controllers - P, PI, PID Control - Control Modes – Position, Velocity And Torque - Multi Axis Interpolation, PTP, Linear, Circular - Core Functionalities – Home, Record Position, Go To Position - Applications

TEXT BOOKS:

1. Mahalik. **Mechatronics**. McGraw-Hill.
2. W Bolton. **Mechatronics Electronics Control Systems in Mechanical and Electrical Engg.** Pearson Edu. Press, 3rd Ed.
3. M.D.Singh and J.G.Joshi. **Mechatronics**. PHI.

REFERENCE BOOKS:

1. Newton C Braga. **Mechatronics Source Book**. Thomson Publications, Chennai.
2. N. Shanmugam and Anuradha. **Mechatronics**. Agencies Publishers.
3. Devdas shetty and Richard. **Mechatronics System Design**. Thomson.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand the concept of mechatronics.
2. Identify, select, and integrate mechatronic components to meet product requirements.
3. Build a mechatronic system with an integrated computer control using actuators, controls, and mechanical system elements.
4. Gain the fundamental knowledge of robots and automation.
5. Have hand-on skills in developing basic mechatronic products.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	-	-	-	-	-	-	1	3	2
CO2	3	3	3	2	3	1	-	-	1	-	-	1	3	1
CO3	3	2	3	2	3	1	-	-	2	1	2	1	2	2
CO4	2	2	2	2	3	1	2	-	-	-	1	1	2	2
CO5	3	2	3	1	3	-	1	1	3	2	2	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

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SUPPLY CHAIN MANAGEMENT (PROFESSIONAL ELECTIVE -V-3)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E13	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Understand the decision phases and apply competitive and supply chain strategies.
2. Understand drivers of supply chain performance.
3. Analyze factors influencing network design.
4. Analyze the role of forecasting in a supply chain
5. Understand the role of aggregate planning, inventory, IT and coordination in a supply chain.

COURSE CONTENT:**UNIT I:****(L-10)**

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

UNIT II:**(L-10)**

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

UNIT III:**(L-10)**

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Forecasting in Supply Chain: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

UNIT IV:**(L-10)**

Aggregate Planning and Inventories in Supply Chain: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.

UNIT V:**(L-10)**

Coordination in Supply Chain: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

Emerging Trends and Innovations in Supply Chain Management: Digital transformation and technology in supply chains, Role of IoT, Big Data, and AI in supply chain management sustainability and resilience in supply chains, Global strategies and risk management

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TEXT BOOKS:

1. Sunil Chopra and Peter Meindl, Supply Chain Management - Strategy, Planning and Operation, Pearson Education Asia, 2021, 7th Edition.
2. David Simchi-Levi, Philip Kamintray and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, Tata-McGraw Hill, 2007, 3rd Edition.

REFERENCE BOOKS:

1. 3. John J Coyle, Managing Supply Chains A Logistics Approach', Cengage Learning, 2019, 10th Edition.
2. 4. Jeremy F Shapiro, Modelling the Supply Chain', Cengage Learning, 2019, 3rd Edition.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain the strategic role of supply chain management, decision phases, process views, and methods to achieve strategic fit.
2. Identify and assess supply chain performance drivers, metrics, and obstacles affecting strategic alignment.
3. Develop and analyze supply chain network designs, including distribution options, facility location models, and forecasting methods.
4. Apply aggregate planning strategies and inventory control techniques, including safety inventory, to manage uncertainty in supply chains.
5. Analyze coordination issues in supply chains, including transportation choices, IT integration, bullwhip effect, and emerging digital and sustainable supply chain practices.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	–	–	–	–	–	–	1	2	1	1	1
CO2	3	3	1	2	–	–	–	–	–	1	2	1	1	1
CO3	3	3	3	2	2	–	–	–	–	1	3	1	1	1
CO4	3	3	2	2	2	–	–	–	–	1	3	1	1	1
CO5	2	3	2	2	3	2	3	1	1	1	2	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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**MAINTENANCE ENGINEERING AND MANAGEMENT
(PROFESSIONAL ELECTIVE -V-4)**

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E14	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. Introduce the basic concepts, objectives, and importance of maintenance in engineering systems.
2. Provide knowledge of planned preventive maintenance (PPM) and its organization and implementation.
3. Develop understanding of maintenance evaluation and performance measurement techniques.
4. Familiarize students with condition monitoring concepts and techniques for equipment health.
5. Explain the economic aspects of maintenance, including costing, budgeting, audits, and lubrication practices.

COURSE CONTENT:**UNIT I:****(L-10)**

MAINTENANCE CONCEPT: Maintenance Definition, Systems Approach, Challenges in Maintenance, Maintenance Objectives, Maintenance Levels, Responsibilities of Maintenance Department, Types of Maintenance Systems, Benefits and Effects of Maintenance, Concept of Maintainability, Principles of Maintenance Research and Development in Maintenance.

UNIT II:**(L-10)****PLANNED PREVENTIVE MAINTENANCE:**

Scope of Preventive Maintenance, Elements of PPM, Implementation of PPM, Administrative Structure, Work Planning and Scheduling, Workload Estimation, Manpower Estimation, Scheduling PPM, Work-order Procedure, Planned Maintenance Procedure, Effectiveness of Preventive Maintenance, Benefits of PPM, Development of Checklists.

UNIT III:**(L-10)**

MAINTENANCE EVALUATION: Background of Maintenance Function, Need of Evaluation, Maintenance Function Requirements, Benefits of Maintenance Evaluation, Types of Evaluation, Statistical Analysis of Performance, Selection of Work Measurement Methods, Cost of Maintenance Evaluation.

UNIT IV:**(L-10)**

CONDITION MONITORING: Basic Concept, Levels of Condition Monitoring, Condition-Monitoring Techniques, Future of Condition Monitoring.

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UNIT V:**(L-10)****ECONOMIC ASPECTS OF MAINTENANCE:**

Life Cycle Costing, Maintenance Cost, Impact of Maintenance Cost, Maintenance Budget, Cost Control,

Absenteeism and Overtime, Maintenance Audit.

LUBRICANTS AND MAINTENANCE: Lubrication Systems, Role of Lubricants, Hi-tech Oils and Lubricants, Impact of Environment on Lubricants.

TEXT BOOKS:

1. MAINTENANCE ENGINEERING AND MANAGEMENT, Second Edition R.C. Mishra and K. Pathak, 2012 by PHI Learning Private Limited, New Delhi.
2. Garg M.R., "Industrial Maintenance", S. Chand & Co., 1986.
3. Venkataraman, K. and Raghavan, V., Maintenance Engineering and Management, PHI Learning, 2010.

REFERENCE BOOKS:

1. White E.N., "Maintenance Planning", I Documentation, Gower Press, 1979.
2. Higgins L.R., "Maintenance Engineering Hand book", McGraw Hill, 5th Edition, 1988.
3. Armstrong, "Condition Monitoring", BSIRSA, 1988.
4. Davies, "Handbook of Condition Monitoring", Chapman & Hall, 1996.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain maintenance concepts, systems, objectives, and different types of maintenance.
2. Plan and implement preventive maintenance activities, including scheduling, work orders, and checklists.
3. Evaluate maintenance performance using statistical and cost analysis methods.
4. Apply condition monitoring techniques to assess equipment condition and predict failures.
5. Analyze maintenance economics, including life cycle cost, budgeting, cost control, audits, and lubrication practices.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	–	1	–	–	–	–	–	1	1	1
CO2	3	3	3	2	2	–	–	–	1	1	2	1	1	1
CO3	2	3	2	3	1	–	–	–	–	–	3	1	1	1
CO4	2	2	2	3	3	–	1	–	–	–	–	1	1	1
CO5	2	2	2	2	–	1	1	1	1	1	3	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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FINITE ELEMENT METHOD

(PROFESSIONAL ELECTIVE -V-5)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E15	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To impart knowledge of how finite element method works by introducing its basic concepts, steps involved and its comparison with finite difference method (FDM) with the aid of numerical examples.
2. To formulate stiffness matrices of spring and bar/truss elements and to understand the concept of minimization of potential energy via Castigliano's theorem.
3. To give insight into the weighted residual methods (WRM) and deriving elemental stiffness and force matrices of one – dimensional elements based on different approaches including direct, energy, and variational formulations.
4. To teach about beam or flexural elements, two – dimensional triangular, rectangular and quadrilateral elements, and devising procedure for formulation of stiffness matrices and load vectors of such elements.
5. To formulate and analyse two – dimensional elements including isoperimetric elements and inducing the concepts of constant strain triangle (CST), Jacobian, and Gauss Quadrature (numerical integration).

COURSE CONTENT:**UNIT I:****(L-12)**

Basic concepts of the Finite Element Method – Introduction, How does the FEM work – Comparison of Finite Element and Finite Difference Methods. A general procedure for Finite Element Analysis – Pre – processing, Solution and Post – processing. Brief History of Finite Element Method, Examples of Finite Element Analysis.

UNIT II:**(L-12)**

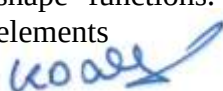
Stiffness Matrices – Spring and Bar Elements – Linear spring as a Finite Element – System Assembly in global coordinates, Elastic Bar, Spar/Link/Truss Element, Strain Energy, Castigliano's Theorem, Minimum Potential Energy

UNIT III:**(L-12)**

Method of Weighted Residuals – Approximate Solution by Ritz, Galerkin Methods – Finite Element formulation of one – dimensional problems – Derivation of Element Stiffness and Element Force Matrices – Different Approaches in FEM: General Steps in FEM – Direct Approach- Variational Approach – Energy approach – Weighted Residual Approach. – Solving one – dimensional (1D) engineering problems and 1D heat transfer problems – fins

UNIT IV:**(L-12)**

Flexural elements – Introduction, Elementary Beam theory, Flexural element, Flexural element stiffness matrix, Element load vector, Work equivalent for distributed loads, Hermite shape functions. 2D elements – liner triangular, bilinear rectangular and quadrilateral elements


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UNIT V: (L-12)

FEA of 2D structural and heat transfer problems, Constant strain triangle (CST), Jacobian, isoparametric and serendipity elements – Numerical integration – Gauss Quadrature – Computer implementation in FEM

TEXT BOOKS:

1. Fundamentals of Finite Element Analysis by David V. Hutton
2. A first course in the Finite Element Method by Daryl L. Logan
3. An Introduction to Finite Element Method by J.N. Reddy

REFERENCE BOOKS:

1. Introduction to Finite Elements in Engineering by Chandrupatla T.R. and Belegundu A.D
2. Finite element procedures by Klaus – Jorgen Bathe

COURSE OUTCOMES: After successful completion of this subject matter, the student will be able to

1. Understand the basic concepts, steps involved, and general procedure in Finite Element Method (FEM) and to differentiate between FEM and finite difference method (FDM).
2. Model and formulate the given physical problem by suitable finite elements such as spring, bar and truss.
3. Utilize different methods of weighted residuals (WRM) – Galerkin, Rayleigh Ritz, Ritz – in formulating and analyzing the one – dimensional engineering problems with the aid of elemental stiffness matrices and force vectors.
4. Analyze the elastic structural members by finite beam elements utilizing the Hermite shape functions and to understand the formulation of two – dimensional elements – three – node triangular, four – node rectangular elements – with suitable examples.
5. Acquaint with FEA of 2D structural and heat transfer problems and abreast of advanced techniques of finite element modelling/analysis such as CST, Jacobian, and Numerical integration.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	1	1	1	1	1	2	1	1	3	2
CO2	3	3	2	2	2	1	1	1	1	2	1	1	3	3
CO3	3	3	2	3	2	1	1	1	1	2	1	1	3	3
CO4	3	3	2	2	2	1	1	1	1	2	1	1	3	3
CO5	3	3	2	3	3	1	1	1	1	2	1	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially



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TRIBOLOGY
(PROFESSIONAL ELECTIVE -V-6)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E16	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To introduce the fundamentals, industrial significance, and surface characterization techniques essential for understanding tribological systems.
2. To study the mechanisms of friction and wear, their measurement techniques, and theoretical models that describe interfacial behavior.
3. To understand the properties, classification, and testing methods of liquid lubricants and greases used in engineering applications.
4. To analyze the fundamental fluid flow equations and derive the Reynolds equation for fluid film lubrication under various assumptions and conditions.
5. To explore the design principles, pressure development mechanisms, and performance characteristics of hydrodynamic thrust and journal bearings.

COURSE CONTENT:**UNIT I:****(L-10)****TRIBOLOGY:** Introduction, History, Industrial Importance.**ENGINEERING SURFACES-PROPERTIES AND MEASUREMENT:**

Introduction, Measurement Methods: Surface Profilometry, Optical Microscopy, Electron Microscopy, Statistical Description: Centre Line Average (CLA), Root Mean Square (RMS) Roughness, Abbott Bearing Area Curve, Probability Distribution Function, Auto-correlation Function (ACF), Slope and Curvature, Power Spectral Density Function (PSDF)

UNIT II:**(L-10)**

FRICTION: Introduction, Measurement Methods: Inclined Plane Rig, Pin-on-disk Rig, Conformal and Non-conformal Geometry Rig, Environment Control, Friction Theories: Bowden and Tabor's Simple Adhesion Theory, Modified Adhesion Theory: Junction Growth, Deformation Theory: Ploughing.

WEAR: Introduction, Types of Wear, Adhesive Wear, Abrasive Wear, Corrosive Wear, Fatigue Wear,

Minor Forms of Wear, Delamination Theory of Wear.



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UNIT III: (L-10)**LIQUID LUBRICANTS-PROPERTIES AND MEASUREMENT:**

Introduction, Oil Lubricants: Natural Organics and Synthetic Organics. Greases, Viscosity: Effect of Temperature, Pressure and Shear Rates on Viscosity, Viscosity Measurement, Relative Density, Specific Heat and Thermal Conductivity, Acidity and Alkalinity, Oxidation Stability, Flash Point, Foaming, Pour Point, Demulsibility, Extreme-pressure Properties, Additives.

UNIT IV: (L-10)**BASIC EQUATIONS FOR FLUID FILM LUBRICATION :**

Introduction, Navier-Stokes Equation: Surface Forces, Body Forces, Inertia Forces, Equilibrium, Continuity Equation, Reynolds Equation: From Principle of Mass Conservation and Laws of Viscous Flow, From Navier-Stokes and Continuity Equations, Significance of Different Terms, Special Cases. Dimensionless Numbers: Reynolds Number, Taylor Number, Froude Number, Euler Number. Flow Rate and Shear Force.

UNIT V: (L-10)**HYDRODYNAMIC THRUST BEARINGS:**

Introduction, Pressure Development Mechanism, Plane Slider Bearing with Exponential Film Profile, Fixed Inclination Slider Bearing, Tilting Pad Slider Bearing, Parallel Step Slider Bearing, Finite Width Thrust Bearings.

HYDRODYNAMIC JOURNAL BEARINGS:

Introduction, Infinitely Long-journal Bearing: Full-Sommerfeld Boundary Condition, Half-Sommerfeld Boundary Condition, Reynolds Boundary Condition. Infinitely Short-Journal Bearing.

TEXT BOOKS:

1. Prasanth Sahoo : Engineering Tribology, PHI Learning Private Limited, 2011
2. Bhushan, B.: Introduction to Tribology, Second Edition, John Wiley & Sons, 2013.
3. Hamrock, B. J., Schmid, S. R., and Jacobson, B. O.: Fundamentals of Machine Elements and Tribology: Principles and Applications of Tribology, McGraw Hill Education, 2004.

REFERENCE BOOKS:

1. Hutchings, I. M. and Shipway, P.: Tribology: Friction and Wear of Engineering Materials, Second Edition, Butterworth–Heinemann, 2017.
2. Neale, M. J.: Applied Tribology: Bearing Design and Lubrication, Second Edition, Butterworth–Heinemann, 1995.
3. Stachowiak, G. W. and Batchelor, A. W.: Engineering Tribology, Fourth Edition, Butterworth–Heinemann (Elsevier), 2014.



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COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain the fundamentals of tribology, describe surface characteristics, and evaluate surface roughness parameters using appropriate measurement methods.
2. Analyze different types of friction and wear, their mechanisms, and evaluate conditions influencing their behaviour in engineering systems.
3. Assess the properties and performance of various liquid lubricants and greases through suitable testing and measurement techniques.
4. Derive and apply the Reynolds equation to analyze pressure distribution and flow in fluid film lubrication.
5. Design and evaluate the performance of hydrodynamic thrust and journal bearings under different operating conditions.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	1	1	–	–	1	–	2	2	1
CO2	3	3	2	2	1	1	1	–	–	–	–	2	2	1
CO3	3	2	2	3	3	1	1	–	–	1	–	2	2	1
CO4	3	3	2	2	2	1	1	–	–	–	–	1	2	1
CO5	3	3	3	2	2	1	1	–	–	1	2	2	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially



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PROJECT MANAGEMENT
(PROFESSIONAL ELECTIVE -VI-1)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E21	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Explain the fundamental concepts, need, and philosophy of project management.
2. Develop the ability to identify, select, and plan projects using structured feasibility and planning techniques.
3. Illustrate the significance of organizational structures, leadership styles, and team management in project environments.
4. Analyze and evaluate project performance through appropriate measurement and control mechanisms.
5. Apply project execution and control methodologies to ensure successful project completion within constraints.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

Basics of Project Management: Introduction, Need for Project Management, Project Management Knowledge Areas and Processes, The Project Life Cycle, The Project Manager (PM), Phases of Project Management Life Cycle, Project Management Processes, Impact of Delays in Project Completions, Essentials of Project Management Philosophy, Project Management Principles.

UNIT II:**(L-12 + P-0 =12)**

Project Identification and Selection: Introduction, Project Identification Process, Project Initiation, Pre-Feasibility Study, Feasibility Studies, Project Break-even point Project Planning: Introduction, Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Break down Structure

UNIT III:**(L-12 + P-0 =12)**

Organisational Structure and Organisational Issues: Introduction, Concept of Organisational Structure, Role and Responsibilities of Project Leader, Relationship between Project Manager and Line Manager, Leadership Styles for Project Managers, Team Management and Diversity Management, Change management.

UNIT IV:**(L-12 + P-0 =12)**

Project Performance Measurement and Evaluation: Introduction, Performance Measurement, Productivity, Project Performance Evaluation, Benefits and Challenges of Performance Measurement and Evaluation, Controlling the Projects.

UNIT V:**(L-12 + P-0 =12)**

Project Execution and Control: Introduction, Project Execution, Project Control Process, Purpose of Project Execution and Control.

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TEXT BOOKS:

1. Prasanna Chandra, Projects, Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill Pvt. Ltd., New Delhi.
2. K. Nagrajan, Project Management, New Age International Publishers,
3. R. Paneerselvam, P. Senthil Kumar, Project Management, PHI.

REFERENCE BOOKS:

1. Vasanth Desai, Project Management, Himalaya Publications.
2. Clifford F. Gray, Erik W. Larson, Project Management, the Managerial Emphasis, Tata McGraw Hill.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Understand the basic concepts, principles, and life cycle of project management.
2. Identify and evaluate suitable projects through feasibility and break-even analysis
3. Demonstrate understanding of organizational structures, leadership roles, and teamwork in project management
4. Assess project performance using productivity and evaluation techniques.
5. Apply project execution and control processes to manage time, cost, and quality effectively.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	2	3	1	1	1	1	2	2	2
CO2	3	2	2	2	2	1	3	1	1	2	1	1	2	2
CO3	3	2	2	2	1	1	3	1	1	2	2	2	2	2
CO4	3	2	2	2	1	1	3	1	2	2	2	1	2	2
CO5	3	2	2	2	2	1	2	1	1	2	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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HYBRID ELECTRIC VEHICLES

(PROFESSIONAL ELECTIVE -VI-2)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E22	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to

1. Understand the fundamentals and necessity of hybrid and electric vehicles.
2. Study various configurations and operating principles of electric and hybrid drive systems
3. Analyze the design parameters and energy requirements for electric vehicles.
4. Gain knowledge on energy storage devices, fuel cells, and battery management systems.
5. Learn about electric propulsion systems, power split devices, and hybrid control strategies.

COURSE CONTENT:**UNIT I:****(L-12 + P-0 =12)**

Introduction to Hybrid and Electric Vehicles: Need for hybrid and electric vehicles – main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Comparative study of diesel, petrol, hybrid, fuel-cell and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles. Case study on specification of electric and hybrid vehicles.

UNIT II:**(L-12+ P-0 =12)**

Design and Performance Requirements of Electric Vehicles: Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistance- Transmission efficiency- Electric vehicle chassis and Body Design, Electric Vehicle Recharging and Refuelling Systems.

UNIT III:**(L-12 + P-0 =12)**

Energy Storage Systems and Fuel Cells for Electric Vehicles: Battery Parameters- Different types of batteries. Battery Chemistry, Battery Modelling, Battery Management System, Thermal Management system. Ultra-capacitors. Fuel Cell Characteristics - Fuel cell types- Electrolytic reactions of fuel cell.

UNIT IV:**(L-12 + P-0 =12)**

Electric Motors, Drives, and Control Systems: Types of Motors, Characteristic of DC motors, AC single phase and 3-phase motor, PM motors, switched reluctance motors, BLDC motor, Motor Drives and speed controllers, Torque Vectoring, Regenerative Braking.

UNIT V:**(L-12 + P-0 =12)**

Hybrid Vehicle Power Split Devices and Control Strategies: Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle- Economy of hybrid Vehicles.


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TEXT BOOKS:

1. James Larminie and John Lowry, "Electric Vehicle Technology Explained "John Wiley & Sons,2003
2. Iqbal Husain, "Electric and Hybrid Vehicles-Design Fundamentals", CRC Press,2003
3. Mehrdad Ehsani, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", CRC Press,2005
4. C.C. Chan and K.T. Chau – *Modern Electric Vehicle Technology*, Oxford University Press.
5. Ali Emadi – *Advanced Electric Drive Vehicles*, CRC Press.

REFERENCE BOOKS:

1. Ron HodKinson, John Fenton, "Light Weight Electric/ Hybrid Vehicle Design", Butterworth Heinemann Publication,2005
2. Lino Guzzella, "Vehicle Propulsion System" Springer Publications,2005

COURSE OUTCOMES: Upon completion of this course, the students will be able to

- 1.Explain the need, structure, and working of hybrid and electric vehicles.
- 2.Analyze performance design requirements and vehicle dynamics of electric vehicles
- 3.Describe different types of batteries, ultra-capacitors, and fuel cells used in electric mobility.
- 4.Compare characteristics and control methods of various electric propulsion motors.
- 5.Illustrate hybrid vehicle power split mechanisms, operation modes, and control strategies for fuel economy.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
CO2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
CO3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
CO4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
CO5	3	3	3	3	3	2	2	1	2	1	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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FLEXIBLE MANUFACTURING SYSTEM

(PROFESSIONAL ELECTIVE -VI-3)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E23	ME

Pre-Requisites: None

COURSE OBJECTIVES: The main learning objective of this course is to

1. Understand the fundamentals of flexible and rigid manufacturing systems, FMS components, flexibility tests, and selection criteria.
2. Gain knowledge of FMS control architecture, automated workpiece flow, hierarchical control levels, factory networks, and diagnostics.
3. Learn tooling and fixturing concepts used in FMS, including modular tooling, tool databases, fixture design methodologies, and robotized tool management.
4. Acquire knowledge on database management systems, data structures, material handling systems, AGVs, AS/RS, and robotic operations in FMS.
5. Develop the ability to design, model, and simulate FMS layouts using appropriate simulation software like ARENA or FLEXSIM for performance evaluation.

COURSE CONTENT:**UNIT I:****(L-10)****INTRODUCTION:**

Flexible and rigid manufacturing, Concept of F.M. Cell and F.M. System, Functions of a manufacturing cell, Types and components of FMS, Tests of flexibility, Group Technology and FMS, Optimization of FMS, Tasks in selection of FMS.

UNIT II:**(L-10)****CONTROL STRUCTURE OF FMS:**

Architecture of typical FMS, Automated work piece flow in FMS, Hierarchical control system architecture of FMS – Factory level, Cell level and Equipment level; Factory networks, Distributed Numerical Control (DNC), unmanned operation, FMS Diagnostics.

UNIT III:**(L-12)**

TOOLING IN FMS: Tool holders for CNC machines, modular tooling, tool monitoring; preset, offset and wear compensation values, robotized tool assembly, tool database, tool management system, tool flow control in FMS.

FIXTURING IN FMS: Palletizing of parts, pallet pool, flexible fixturing – principles and methodologies, standard fixtures, modular fixturing system – T-slot based and dowel pin based and their components; Computer aided fixture design – approaches, use of GT in fixture design – fixture design process, fixturing structure and fixturing information tree, fixture database.

UNIT IV:**(L-12)****DATABASE MANAGEMENT SYSTEMS IN FMS:**

Conceptual DBMS, types of data structures and their applications in FMS, Integrated DBMS in FMS and its implementation.



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MATERIAL HANDLING IN FMS:

Functions of an integrated material handling system in FMS, Flexibilities in material handling, Layouts in FMS, Industrial robots for load / unload applications, Robotic cell layouts; Automatically Guided Vehicles (AGVs) – types, Control of AGVs- Wire guided, optically guided, dead reckoning, free ranging AGVs, Scheduling of AGV, Storage and retrieval machines in AS/RS.

UNIT V:**(L-10)****DESIGNING AND SIMULATING FMS:**

Need, techniques, inputs, procedure, performance analysis, Simulation of FMS shop, using Simulation software package (like ARENA or FLEXSIM) including various modules like Arrive, Server, Depart, Simulate modules, Creating models of FMS shops and simulating the performance to obtain output results.

TEXT BOOKS:

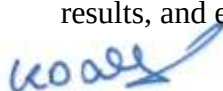
1. Flexible Manufacturing Systems in Practice Applications, Design And Simulation, Joseph Talavage et. al: , Taylor and Francies Publisher: US.
2. Computer Integrated Design and Manufacturing, Bedworth el.al, Tata McGrawHill,(1991).
3. Performance Modeling of Automated Manufacturing Systems, N. Viswanadham, Y. Narhari,Prentice Hall Publication, (1992).
4. Automation, Production Systems and Computer Integrated Manufacturing, Groover, Pearson Education.

REFERENCE BOOKS:

1. FMS, H K Shivanand, New Age International Publication.
2. The Design and Operation of FMS, Ranky, Dr. Paul, (1984).
3. Simulation with ARENA, Kelton, Sadowsky and Sadowsky, Tata McGraw Hill International Editions (with CD of ARENA Simulation Software), 2nd Edition.
4. Flexible Manufacturing Cells and Systems, W.W. Luggen, Publication, Prentice Hall of India.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain the fundamentals of flexible manufacturing, identify FMS components, and analyze flexibility parameters for selecting appropriate FMS setups.
2. Describe the hierarchical control structure of FMS and evaluate automated workpiece flow, factory networking, DNC, and diagnostic systems.
3. Apply tooling and fixturing concepts, including tool monitoring, modular tooling, palletizing, fixture design methodologies, and database-based tool/fixture management in FMS.
4. Analyze database structures and material handling systems such as AGVs, AS/RS, and robotic layouts, and their integration within FMS.
5. Design and simulate FMS models using software tools, interpret simulation results, and evaluate system performance for efficient manufacturing.


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Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
C01	3	2	1	1	2	1	1	1	1	1	1	2	3	1
C02	2	3	2	2	2	1	1	1	1	1	1	2	3	1
C03	3	2	3	2	3	1	1	1	1	1	1	2	3	1
C04	3	3	2	2	3	1	1	1	1	1	1	2	3	1
C05	3	3	3	3	3	1	1	1	2	1	1	3	3	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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DESIGN AND ANALYSIS OF EXPERIMENTS (PROFESSIONAL ELECTIVE -VI-4)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E24	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To introduce the fundamentals and principles of experimentation in engineering.
2. To understand basic statistical concepts used in comparative experiments.
3. To learn different experimental design techniques for data analysis.
4. To study response surface methodology for process optimization.
5. To understand Taguchi's approach for robust parameter design.

COURSE CONTENT:**UNIT I:****(L-10)**

Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.

UNIT II:**(L-10)**

Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.

UNIT III:**(L-10)**

Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

UNIT IV:**(L-10)**

Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression.

UNIT V:**(L-10)**

Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.



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TEXT BOOKS:

1. Montgomery D. C., Design and Analysis of Experiments, John Wiley & Sons, 2010, 7th Edition.
2. Ross P. J., Taguchi Techniques for Quality Engineering, McGraw-Hill, NY, 2008.
3. Madhav S. Phadke, Quality Engineering using Robust Design, Prentice Hall, 1989

REFERENCE BOOKS:

1. Dukkupati, R V and Pradip K Ray, Product and Process Design for Quality, Economy and Reliability, New Age International, 2010, 1st Edn.
2. Raghuwanshi, B.S. and Iyer, P.V.R., Experimental Design and Analysis, Oxford & IBH Publishing, 1994.
3. Roy, Ranjit K., A Primer on the Taguchi Method, Society of Manufacturing Engineers (SME), 2010.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain the role and steps involved in engineering experimentation.
2. Apply statistical methods such as comparison of means, variances, and ANOVA.
3. Select and analyze suitable experimental designs using factorial and orthogonal arrays.
4. Apply response surface methodology to develop and analyze regression models.
5. Use Taguchi methods to design robust experiments and analyze results.

Mapping of Course Outcomes with Program Outcomes:

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

1 - Slightly; 2 - Moderately; 3 – Substantially



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ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**(PROFESSIONAL ELECTIVE -VI-5)****Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E25	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To introduce basic concepts of statistics and data analysis for engineering applications.
2. To understand the fundamentals of machine learning techniques.
3. To learn basic deep learning models and their working principles.
4. To develop skills in Python programming for machine learning and data visualization.
5. To apply data science and ML/DL techniques to mechanical engineering problems.

COURSE CONTENT:**UNIT I:****(L-10)**

Basics of Engineering Design and Statistics: Introduction to Statistics – descriptive statistics, dispersion measures, central tendency measures, hypothesis testing, inferential statistics, correlation and regression, p-value, central limit theorem, feature engineering.

UNIT II:**(L-10)**

Machine Learning Algorithms: Basics of AI, ML, & DL. Fundamentals of ML - supervised, unsupervised, reinforcement learning. Supervised machine learning – Regression: linear regression, multilinear regression, non-linear regression, logistic regression. Classification: neural networks, decision trees, random forests, support vector machine, k-nearest neighbour. Unsupervised machine learning – mixture models, hierarchical k-means clustering, principal component analysis.

UNIT III:**(L-10)**

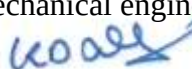
Deep learning Algorithms: Deep feedforward neural nets, Convolutional neural networks, Long short-term memory (LSTM) networks. Introduction to Graph Neural networks, Generative Adversarial Networks, and Reinforcement Learning.

UNIT IV:**(L-10)**

Python for Machine Learning: Getting started with Python, Basic Commands, working with Python libraries, Loops, Variables, Data types, and Data visualization, exploring AI through python- neural networks and machine learning in python.

UNIT V:**(L-10)**

Applications: SHM Paradigm, feature extraction, feature importance, correlation, and eigenvalue analyses, feature augmentation, performance and validation of ML/DL models in mechanical engineering applications.


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TEXT BOOKS:

1. Thomas Nield, Essential Math for data science, Oreilly, June 2022
2. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning, Packt Publishing, 2019.

REFERENCE BOOKS:

1. Marc peter, Aldo Faisal, Cheng soon, Mathematics for Machine learning, Cambridge, 2021
2. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, Wiley, 2018.
3. Tom M. Mitchell, Machine Learning, McGraw-Hill, 1997.

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Apply basic statistical methods to analyze engineering data.
2. Use suitable machine learning algorithms for prediction and classification.
3. Understand and apply basic deep learning models.
4. Implement machine learning algorithms using Python tools.
5. Apply ML/DL techniques to mechanical engineering applications such as SHM.

Mapping of Course Outcomes with Program Outcomes:

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

1 - Slightly; 2 - Moderately; 3 – Substantially



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LEAN MANUFACTURING AND SIX SIGMA (PROFESSIONAL ELECTIVE -VI-6)

Credits: 3**Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-5-7-R25E26	ME

Pre-Requisites: None**COURSE OBJECTIVES:** The main learning objective of this course is

1. To introduce the basic concepts of Six Sigma, variation, sigma levels, and quality costs.
2. To familiarize students with Lean manufacturing tools and Six Sigma methodologies used for process improvement.
3. To develop an understanding of process management, continuous improvement methods, and Six Sigma integration with production systems.
4. To understand Lean elements, zero-defect concepts, and efficient utilization of resources in organizations.
5. To learn the implementation aspects of Six Sigma and Lean systems, including audits, monitoring, and continuous improvement practices.

COURSE CONTENT:**UNIT I:****(L-10)**

BASICS OF SIX SIGMA: Introduction to 6 Sigma, basic tools of six sigma like problem solving approach, standard deviation, normal distribution, various sigma levels with some examples, value for the enterprise, Variation, and sources of variation, Mean and moving the mean, Various quality costs, cost of poor quality.

UNIT II:**(L-10)**

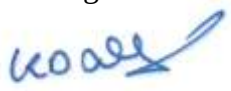
INTRODUCTION TO LEAN MANUFACTURING TOOLS: Process Capability Indices, Cause and Effect diagram, Control Charts, Introduction to FMEA, APQP, PPAP. 3 foundational 6 Sigma methodologies: DMAIC, DMEDI, and Process Management DMEDI for process creation, DMAIC for process improvement and PDCA for sustaining improvements.

UNIT III:**(L-10)**

DEEPER UNDERSTANDING METHODOLOGIES: What is a process, Why Process management, Keys to process management, Difference between process management and 6 Sigma, Introduction to Deming cycle, PDCA, DMAIC and continuous improvement, DMEDI for creation process, DMAIC Vs DMEDI with examples, Introduction to Toyota Production System, Six Sigma and Production System integration.

UNIT IV:**(L-10)**

LEAN ELEMENTS: Introduction to Lean Concepts like In-Built Quality, Concept of Right Part at the Right Time, Lead Time reduction, Optimum utilization of Capital, Optimum utilization of People. Understanding the Zero-defect concept and Metrics, Focus on Human Resources, Quality, Delivery, Cost. Building Zero defect capabilities, Cultural and Organizational aspects


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UNIT V:**(L-10)**

IMPLEMENTATION AND CHALLENGES: Implementing Checks and Balances in the process, Robust Information Systems, Dashboard, follow up and robust corrective and preventive mechanism. Concept of Audits, and continuous improvement from gap analysis, risk assessments etc.

TEXT BOOKS:

1. JM Juran & FM Gryna, Quality Planning and Analysis-. Tata Mc Graw Hill, 2017
2. Akhilesh N. Singh, Lean Manufacturing: Principles to Practice, L.B. Associates Pvt. Ltd. 2019
3. The Toyota Way: 14 Management Principles, Tata Mc Graw Hill, 2020

REFERENCE BOOKS:

1. Quality Council of India <https://qcin.org/> & its library.
https://qcin.org/nbqp/knowledge_bank/
2. Thomas Pyzdek & Paul A. Keller, The Six Sigma Handbook, McGraw-Hill, 2014
3. International Society of Six Sigma Professionals: <https://isspp.org/about-us/>

COURSE OUTCOMES: Upon successful completion of the course, the student will be able to:

1. Explain Six Sigma concepts, sources of variation, sigma levels, and cost of poor quality.
2. Apply Lean tools and Six Sigma methodologies such as DMAIC and DMEDI for process analysis and improvement.
3. Differentiate between process management approaches and apply continuous improvement concepts in manufacturing systems.
4. Apply Lean principles and zero-defect concepts to improve quality, delivery, and cost performance.
5. Implement monitoring, audits, and corrective actions for sustaining continuous improvement in organizations.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	1	1	–	–	–	–	–	–	1	1	1
CO2	3	3	2	2	2	–	–	–	–	–	–	1	1	1
CO3	3	3	2	2	2	–	–	–	–	–	–	1	1	1
CO4	3	3	3	2	2	–	1	–	1	1	–	1	1	1
CO5	2	2	2	2	2	–	–	–	1	1	2	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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B. Tech. (Mechanical Engineering)
Semester VIII (Fourth Year)

Code		Category	Course Title	Hours/Week			Total	Credits	Marks		
Department	University			L	T	P			CIE	SEE	Total
ME 5801PI	7-0-8-R25PS	ME-PWSI	Project Work & Full Semester Internship	0	0	24	24	12	50	50	100
TOTAL				0	0	24	24	12	50	50	100

In the final semester, the student should mandatorily undergo full semester internship and parallelly he/she should ***work on a project with well-defined objectives***. At the end of the semester the candidate shall submit an internship report and its completion certificate in the department. Student is permitted to submit report on the work carried out during the internship as project report provided the internship work is in the discipline of his B.Tech. Program. Internship programs offered by AICTE/APSSDC/NSDC/SWAYAM PLUS /Any State or Central Government organizations involving Industry experts and approved by the concerned BoS/Head/Head of the Institution are also considered equivalent to full semester Internship provided it involves 90 – 120 hours of work. The Internship work area can be in his own discipline or inter-disciplinary (One discipline being his own) or other discipline also. The project work shall be either in the discipline of his own or inter-disciplinary.



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EXIT OPTIONS FOR B. TECH MECHANICAL ENGINEERING – R25 REGULATIONS

**Two months internship in industry or bridge courses mentioned below of 6 to 8 credits
on NPTEL – SWAYAM Platform**

Semester	Exit Option	Credits	Additional Credits for exit students	List of exit courses
Sem I & II	U.G Certificate	40	6-8	1. Manufacturing Process Technology – I & II 2. Thermodynamics Basics 3. Introduction to Fluid Mechanics 4. Kinematics of Mechanism and Machining 5. Metal cutting and Machine Tools
Sem III & IV	U.G Diploma	43.5	6-8	1.Measurement and instrumentation 2.Heat Transfer 3.Introduction to Operation Research 4.Dynamics and Control of Mechanical Systems 5.Design of Mechanical Transmission Systems
Sem V & V1	B.E Vocational	48.5	-	NIL


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