Jharkhand University of Technology

Ranchi, 834010

SCHEME OF INSTRUCTION AND SYLLABUS

For B.Tech. Program in

Mechanical Engineering

(Effective from 2024-25)

DEPARTMENT OF MECHANICAL ENGINEERING

(3rd – SEMESTER)

Transformation Techniques and Complex Variable

BSC301

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Introduce the application of Laplace Transform and solution of engineering problems in the form of differential equations.
CO2	Develop the understanding of transform the signal from time domain into frequency domain using Fourier Transform
CO3	Introduce z-transform and its application in the solution of difference Equation
CO4	Analyze engineering problems of fluid mechanics, Thermodynamics and electric field involving complex functions.
CO5	Understand the conceptual knowledge of integration over contour having complex variables.

Syllabus Unit Wise, Teaching Hours

Unit 1 **(10 hours)**

Laplace Transform

Laplace Transform and Its Properties, Transform of Derivatives, Transform of Integrals, Inverse Laplace transform, Convolution Theorem, Unit Step Function, Unit Impulse Function, Solution of ODE by Laplace Transform.

Unit 2 **(7 hours)**

Fourier transform

Fourier Integrals, Fourier Transform and Properties, Fourier Sine Transform, Fourier Cosine Transform, Inverse Fourier Transform, Inverse Fourier Sine and Cosine Transform.

Unit 3 **(8 hours)**

Z- Transform

Z-transform, Properties of Z-Transform, Initial and Final value Theorem, Convolution Theorem, Inverse Z-Transform, Solution of Difference Equation using Z-transform.

Unit 4 **(9 hours)**

Complex Variable: Differentiation

Derivative of Complex Functions, Analytic Function, Cauchy-Riemann Equation, C-R Equation in Polar form, Harmonic Function, Milne-Thomson's Method, Harmonic Conjugate, Conformal Mapping, Bilinear Mapping, Mobius Tranformation and their Properties.

Unit 5 **(8 hours)**

Complex Variable: Integration

Contour Integral, Cauchy's Integral Theorem, Cauchy's Integral Formula, Taylor's Series, Laurent's Series, Zeros and singularity of Analytic Function, Poles and Residues, Cauchy's Residue Theorem and Evaluation of Integrals.

Materials and access:

Textbooks:

1. Advanced Engineering Mathematics (10th edition) by Erwin Kreyszig, Wiley Eastern Ltd.

2. The Laplace Transform: Theory and Application, Joel L. Schiff.

3. N.P. Bali And Manish Goyal, A Text Book Of Engineering Mathematics, Laxmi Publications, Reprint, 2008.

Reference Books:

1. J. W. Brown And R. V. Churchill, Complex Variables And Applications, 7th Edition, Mc- Graw Hill, 2004.

2.M. J. Ablowitz and A. S. Fokas, Complex Variables- Introduction and Applications, Cambridge University Press, 1998 (Indian Edition).

3. G.B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 9th Edition, Pearson, Reprint, 2002.

4. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 42nd Edition.

ENGINEERING THERMODYNAMICS

MEC302

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Apply relevant thermodynamic relations based on the type of working fluid.
CO2	Evaluate thermodynamic properties and moving boundary work based on the type of process.
CO3	Apply the first law of thermodynamics to closed and open systems to arrive solutions.
CO4	Check the feasibility of a thermodynamic system and evaluate its performance by applying the second law of thermodynamics.
CO5	Apply entropy and exergy balance to closed and open systems for the performance evaluation.
CO6	Express the derived properties in terms of measurable properties.

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1		1								1			
CO2	3	3	1										1			
CO3	3	3	3			1	1						1			
CO4	3	3	3		1								1			
CO5	3	3	3		1								1			
CO6	3	3	1										1			

Course Objectives

The course will enable the students to

- Educate the properties of ideal gases, real gases, and pure substances.
- Elucidate basic concepts and thermodynamic properties.
- Familiarize with various laws of thermodynamics.

• Instruct the method of applying energy, entropy, and exergy balance to systems. • Distinguish the measurable and non-measurable properties.

Syllabus

Unit 1

Properties of working fluids: ideal gas behavior, real gas behavior, equation of state, compressibility factor, compressibility chart, properties of pure substance. Basic concepts and Thermodynamic properties: system, surroundings, boundary, properties, state and equilibrium, process, cycle, temperature, pressure and specific volume, heat and work, internal energy and enthalpy. **[12 hours]**

Unit 2

Laws of Thermodynamics:

Zeroth law: thermal equilibrium, temperature measurement in various scale, First law: static and dynamic form of energy, law of conservation of energy, energy balance to closed and open systems – steady and unsteady flow devices and limitations of the first law of thermodynamics [**6 hours**]

Unit 3

Second law: Kelvin-Planck and Clausius statements, Carnot theorem, Clausius inequality, the concept of entropy, principle of increase of entropy, Third law: absolute entropy **[6 hours]**

Unit 4

Entropy and Exergy Balance: Irreversibility's change in entropy, entropy transfer by heat and mass, entropy generation, entropy balance applied to closed and open systems. Available and unavailable energy, exergy destruction, second law or exergetic efficiency, exergy transfer by heat, work and mass, exergy balance applied to closed and open systems. **[10 hours]**

Unit 5

Thermodynamic property relations: Maxwell relations, Clausius-Clapeyron equation, change in internal energy, change in enthalpy, change in entropy relations, Joule Thomson coefficient and inversion line. **[8 hours]**

Textbooks:

1. Cengel Y. A. and Boles M. A., "Thermodynamics – an Engineering Approach", 8/e, Tata McGraw hill, 2016

Reference Books:

1. Sonntag R. E., Borgnakke C. and Van Wylen, G., "Fundamentals of Thermodynamics", , John Wiley and Sons, 2008
2. Pramod Kumar and Atul Dhar., "Basics of Thermodynamics", 1/e, AICTE, 2023
3. Michael J. Moran and Howard N. Shapiro., "Fundamentals of Engineering Thermodynamics", 9/e, John Wiley and Sons, Inc., 2018

Fluid Mechanics

MEC303

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Apply conservation laws to fluid flow problems in engineering applications
CO2	Design experimental procedure for physical model studies.
CO3	Use of different fluid flow measuring devices.
CO4	Compute drag and lift coefficients using the theory of boundary layer flows.
CO5	Analyze and design pipe flows.

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	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	PSO 3	PSO 4
CO 1	3	3	2	2					1	1		2	2	1		
CO 2	3	3	3	3					1	1		2	2	1		
CO 3	2	1	3	1	1				1	1		1	2	1		
CO 4	2	1	3	2				1	1	1		1	2	1		
CO 5	3	2	3	2	1				1	1		1	2	1		

1 - Slightly; 2 - Moderately; 3 – Substantially

Unit 1

Introduction: Importance of fluid mechanics and its application to various engineering areas, fluid and its classification: ideal, real, Newtonian, non-Newtonian fluids, characteristic properties of fluids. Surface Tension, Capillary, Compressibility, Bulk modulus, fluid viscosity, density, vapor pressure, cavitation.
[08 Hours]

Unit 2

Statics: Pressure at a Point, Standard Atmosphere, Measurement of Pressure: Manometry, Mechanical and Electronic Pressure-Measuring Devices, Hydrostatic Force on a Plane and Curved Surface, Buoyancy, Flotation, and Stability. **[08 Hours]**

Unit 3

Description of fluid flow: with reference to translation, rotation and deformation concept of continuum, control mass & control volume approach, Reynolds transport theorem. Steady flow and uniform flow.

Velocity field, one & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flow net.
Continuity equation, Euler's equation of motion, Bernoulli's equation and its applications in flow measurement, Impulse momentum equation and applications. **[10 Hours]**

Unit 4

Dimensional Analysis as a tool in design of experiments, identification of non-dimensional numbers and their significance, dimensional analysis methods.
Equations of motion for laminar flow of a Newtonian fluid - Viscous flow - Navier-Stoke's equations, simple exact solutions for Hydrodynamic lubrication. **[08 Hours]**

Unit 5

Boundary Layer Theory-Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces-Mathematical models for boundary layer flows. smooth rough and transitional turbulent flow in pipes, pipe resistance equation for pipes design of pipe networks.
[08 Hours]

Learning Resources:

Text Books:

1. Philip M. Gerhart, John I. Hochstein, Andrew L. Gerhart, "Fundamentals of Fluid Mechanics", 9th Edition, Wiley, 2021
2. Fluid Mechanics Franck .M White Tata Mc GrawHill Publication 2011.

Reference Books:

1. Shames, "Mechanics of Fluids", McGraw Hill Book Co., New Delhi, 1988
2. Streeter V.L., Benjamin Wylie, "Fluid Mechanics", Mc Graw Hill Book Co., New Delhi, 1999.

Mechanics of Solids

MEC 304

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Apply the fundamental principles to estimate the deformation and stress of linear elastic solids under axial loading.
CO2	Calculate principal stresses and identify principal planes.
CO3	Construct shear force and bending moment diagrams
CO4	Evaluate bending stress in beams.
CO5	Calculate slope and deflection in beams.
CO6	Compute stress in shafts subjected to torsion.
CO7	Determine stress developed in pressurized thin cylinder.
CO8	Compare Euler's and Rankine's buckling load of columns under different end conditions.

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	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	PSO 3	PSO 4
CO 1	3	3	2									1	2	1		
CO 2	3	3	2									1	2	1		
CO 3	3	3	2									1	2	1		
CO 4	3	3	2									1	2	1		
CO 5	3	3	2									1	2	1		
CO 6	3	3	2									1	2	1		
CO 7	3	3	2									1	2	1		
CO 8	3	3	2									1	2	1		

Course Objectives

The course will enable the students to

- Understand the theory of linear elastic response of materials subjected to different types of loads
- Evaluate the deformation and stress of elastic materials under axial, torsional, and transverse loading conditions

- Construct shear force, and bending moment diagrams
- Familiarize the stress of pressurized cylinders
- Evaluate the buckling load of columns

Syllabus

Unit 1

Simple Stress and Strain: Introduction, Properties of materials, Stress, Strain, Hook's Law, Poisson's ratio, Stress-Strain Diagram for structural steel, Principles of superposition, Total elongation of tapering bars of circular and rectangular cross sections. Elongation due to self-weight, Composite sections, Volumetric strain, Elastic constants, Relationship among elastic constants, Thermal stresses in compound bars. Strain Energy & Impact loading. **[10 Hours]**

Unit 2

Compound Stresses: Introduction, Stress components on inclined planes, General two-dimensional stress system, Principal planes and stresses and Mohr's circle of stresses. Thin Cylinders and Shells: Analysis of thin cylindrical shells **[6 Hours]**

Unit 3

Bending Moment and Shear Force in Beams: Introduction, Types of beams, loadings and supports, Shear force in beam, bending moment in beam, Sign convention, Relationship between loading, shear force and bending moment, Shear force and bending moment equations, SFD and BMD with salient values for Cantilever beams, simply supported beams and Overhanging beams considering Point loads, UDL, UVL and Couple. Bending and shear stresses in beams. **[8 Hours]**

Unit 4

Deflection of beams: Introduction, Definition of Slope, Deflection, Elastic curve, Deflection using Macaulay's method, Moment Area method for prismatic beams subjected to transverse Point loads, UDL and Couple. **[6 Hours]**

Unit 5

Torsion of Circular Shafts: Introduction pure torsion, Torsion equation of circular shafts, Torsional rigidity and polar modulus, Power transmitted by shaft of solid and hollow circular sections. **[6 Hours]**

Unit 6

Elastic Stability of Columns: Introduction, Short and long columns, Buckling load, Euler's theory on columns, Derivation, Effective length, Slenderness ratio, Radius of gyration, Limitations of Euler's theory, Rankine's formula, Problems **[6 Hours]**

Textbook:

1. Ferdinand Beer & Russell Johnston – "Mechanics of Materials" - Tata Mc Graw Hill 2020, 8th Edition

Reference Books:

1. James M. Gere, Barry J. Goodno - ‘Mechanics of Materials’ - Cengage Learning Custom Publishing 2021, 9th Edition

2. R. C. Hibbeler, - ‘Mechanics of Materials’ - Prentice Hall - 2022 - 10th Edition

3. Egor. P. Popov – ‘Engineering Mechanics of Solids’ - Pearson Edu. India - 2015 - 2nd Edition

4. Mubeen – ‘Mechanics of Solids’ - Pearson India - 2012 - 2nd Edition

5. W.A.Nash, Schaum’s Outline Series – ‘Strength of Materials’ – 2019 – 7th Edition

MANUFACTURING PROCESS- I

MEC305

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Apply the principles of metal casting processes for ferrous and nonferrous materials involving the design of patterns, molds, and gating and riser system.
CO2	Prepare sand mold, perform casting trials with a non-ferrous material, and conduct a macroscopic inspection of the cast component.
CO3	Understand the principles of plastic manufacturing processes and select suitable processes for the given application.
CO4	Understand the principle of various metal-forming processes and analyze the concept of yield criteria and estimate the formability limits of different materials
CO5	Select suitable metals joining process for the given material and application.
CO6	Design of weld joints, selection of welding parameters, joining ferrous and non-ferrous materials using TIG and MIG welding processes, and macroscopic inspection of weldments.
CO7	Understand the principle of the powder metallurgy process and identify suitable applications.
CO8	Follow safety rules and standard codes of practice during machining.

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	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	PSO 3	PSO 4
CO 1	3	1	2	1		1	1		1	1		1	1	1	2	
CO 2	3	1	2	1		1	1		1	1		1	1	1	2	
CO 3	3	1	2			1	1		1	1		1	1	1	2	
CO 4	3	1	2	1		1	1		1	1		1	1	1	2	
CO 5	3	1	2	1		1	1		1	1		1	1	1	2	
CO 6	3	1	2	1		1	1		1	1		1	1	1	2	
CO 7	3	1	2			1	1		1	1		1	1	1	2	
CO 8						1	1	1	1	1		1	1	1	2	

Course Objectives

The course will enable the students to

- Impart knowledge of fundamental concepts and applications of metal casting, mold preparation with proper gating-riser system, and plastic manufacturing processes.
- Basic principles, effect of process parameters, forming load calculation, formability estimation, and applications of conventional and advanced forming processes.
- Principles, process parameters, and applications of fusion and solid-state welding processes and design of weld joints
- Principles and applications of powder metallurgy processes for producing net-shape parts from metal powders

Syllabus

Unit 1

Casting: Metal casting processes and equipment, shrinkage, principles of gating and riser design, Casting processes - sand, die, gravity, centrifugal, shell mold and Investment casting, Single crystal/ direct solidification processes, Squeeze casting, casting defects, remedies and inspection. **[10 Hours]**

Unit 2:

Metal forming: Plastic deformation and yield criteria; fundamentals of hot and cold working processes, bulk forming processes - forging, rolling, extrusion, drawing and sheet forming processes - shearing, deep drawing, bending, flow forming, advanced metal forming processes – severe plastic deformation- explosive, electro-hydraulic, magnetic pulse and hydroforming.
[10 Hours]

Unit 3:

Metal Joining Processes: Solid state welding process- diffusion, friction, and friction stir welding, Fusion Welding - arc welding, gas welding, resistance welding, submerged arc welding, high energy welding- Laser, Electron Beam, and Plasma, weld defects and inspection, Soldering, brazing, and adhesive bonding. **[10 Hours]**

Unit 4:

Powder Metallurgy: Powder metallurgy- process- powder production, compaction and sintering, applications. Introduction to additive manufacturing process and principles. **[4 Hours]**

Unit 5:

Processing of polymers and composites: Plastic manufacturing processes, calendaring, casting, forming, molding, extrusion, injection, and blow molding, thermoforming. Composite manufacturing techniques: Open and Closed molding, RTM, Hand layup, spraying, Injection molding, compression molding, filament winding, pultrusion. **[8 Hours]**

Textbooks:

1. Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2023 - 8th Edition in SI Units

Reference Books:

1. Amitabha Ghosh and A.K. Mallick, Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.

2. Mikell P Groover, Fundamentals of Modern Manufacturing: Materials, Processes and Systems, 7th Edition, Wiley, 2021.

MACHINE DRAWING AutoCAD

MEC306P

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Understand the standards for creating machine drawings.	Understand
CO2	Apply limits and tolerances to assemblies and choose the appropriate fit.	Apply
CO3	Develop solid models of machine components and assembly, and Construct sectional and orthographic views of components.	Develop
CO4	Apply CAD packages for solid/surface modeling of machine parts and create a bill of materials.	Apply
CO5	Interpret and apply the geometric dimensioning & Tolerancing symbols in the drawing and assembly of solid/surface models of machine components using a CAD package.	Apply

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	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	PSO 3	PSO 4
CO 1	3				3	1			1	3		1	1	1		
CO 2	2				1	1			1	3		1	1	1		
CO 3	1		1		3	1			1	2		1	1	1		
CO 4	1				2	1			1	2		1	1	1		
CO 5	1		1		3	1			2	2		1	1	1		

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Unit 1

Fundamentals of Machine Drawing: Standardization, Inter-changeability, Selective Assembly, Basic principles of GD&T (geometric dimensioning & tolerance), Limits, Fits, Tolerance, Tolerance of form and position, Grades of tolerance, Standard tolerances Machining symbols, Welding symbols, Surface finish indication, Functional and manufacturing datum, Riveted and butt Joints, Fasteners and keys.

Unit 2

Drawing of Machine Elements (Manual & Using Application Packages):

Application package Introduction: Drawing, Editing, Dimensioning, and Assembly.

Shaft joints: Cotter joint and knuckle joint.

Shaft coupling: Muff, Flanged, Flexible, Universal and Oldham's coupling.

Shaft bearing: Solid and bush bearing, Plummer block, Footstep bearing.

Pipe joint: Flanged joint, Socket and Spigot joint, Hydraulic joint, Union joint, Gland & Stuffing Box and Expansion joint.

Sheet metal surface modellings.

Unit 3

Assembly Drawings using prototypes (Manual & Using Application Packages):

Valves: Stop valve, relief valve, safety valve and non- return valve

Machine tool components: Drill Jig, Tail Stock, Tool post, machine vice and screw jack.

Engine: Piston and connecting rod.

Preparation of bill of materials and tolerance data

Project: Students will be assigned to assemble and create three dimensional and part drawings by following standard drawing practices.

Textbooks:

1. Gopalakrishna K. R., "Machine Drawing", 16th Edition, Subhas publishing House, 2002

Reference Books:

1. Narayana K.L., "Machine Drawing", 4th Edition, New Age International publishers, 2010
2. Gill P.S. "A Textbook of Machine Drawing", 18th Edition, S. K. Kataria& Sons, 2013
3. Bhat N.D., and Panchal, V.M., "Machine Drawing" 48th Edition, Charotar Publication House, 2013
4. Ajeet Singh, Machine drawing, 2nd edition, Tata McGraw Hill, India, 2012.

MATERIAL TESTING LABORATORY

MEC304P

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Determine the tensile properties and torsional shear strength of metals.	Evaluate
CO2	Evaluate the stiffness and rigidity of springs and modulus of elasticity of wooden beams.	Evaluate
CO3	Estimate the hardness, shear and impact strength of various materials.	Evaluate
CO4	Prepare the samples and characterize the microstructures of different ferrous and non-ferrous metals / alloys.	Analyze
CO5	Evaluate the effect of various heat treatments on the properties and hardenability of steel	Evaluate
CO6	Analyze the microstructure of the samples using SEM and XRD	Analyze
CO7	Identify the surface defects using NDT	Apply

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	1	1	1		1	1			2	1		
CO2	3	2	1	1	1	1	1		1	1			2	1		
CO3	3	2	1	1	1	1	1		1	1			2	1		
CO4	3	2	1	1	1	1	1		1	1			2		1	
CO5	3	2	1	1	1	1	1		1	1			2		1	
CO6	3	2	1	1	1	1	1		1	1			2		1	
CO7	3	2	1	1	1	1	1		1	1			2		1	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

a) Material testing:

Tension test on metals, Torsion test on mild steel rods, Tension and compression tests on springs (closed coil and open coil), Static bending test on wooden beams, Double shear test on mild steel specimens, Impact tests (Charpy and Izod), Hardness tests (Brinell and Rockwell tests).

b) Metallurgy:

1. Study of metallurgical microscope and sample preparation.
2. Study the microstructure of low, medium, high carbon steel and high-speed steel.
3. Study the microstructure of cast irons.
4. Study the microstructure of Aluminium alloys, copper alloys and Al Metal Matrix Composites.
5. Study the microstructure and hardness measurements of heat-treated steels.
6. Determination of the hardenability of Steels.
7. Scanning Electron Microscope (SEM): working principle and study of tensile fractured and wear tested samples
8. X-Ray Diffraction (XRD): working principle, structure factor and indexing BCC and FCC crystal structures
9. Introduction to Non-destructive testing.

Reference Books:

1. H. E. Davis, G. E. Troxell, G. F. W. Hauck, "The Testing of Engineering Materials", 4ed, McGraw-Hill 1982.
2. G. E. Dieter, "Mechanical Metallurgy", 3ed, McGraw-Hill Book, Co., New York, 1988.
3. P. G. Ormandy "An introduction to metallurgical laboratory techniques", 1st edition, Pergamon series , Canada, 1968, https://doi.org/10.1016/C2013-0-01529-0

List of Equipment required for meeting the COs

a) Material Testing

- Universal Testing Machine
- Deflection of beam
- Torsion test machine
- Brinell and Rockwell test machines
- Impact test machine•

b) Metallurgy

Metallurgical optical microscope

- Brinell hardness test
- Rockwell hardness tester
- Muffle furnace
- Jominy End Quench Test Apparatus
- SEM and XRD
- liquid penetrant test kit

List of Exercises

1. Determination of the tensile properties of metals.
2 .Determination of the stiffness and modulus of rigidity of helical springs.
3. Estimation of the modulus of elasticity of the given wooden beam .
4. Determination of the modulus of rigidity and torsional shear strength of the given material through a torsion test.
5. Find the shear strength of the given specimen.
6. Determination of the hardness of given materials .

7. Determination of the impact strength of the given specimen by the Izod and Charpy impact test.
8. Study of metallurgical microscope and sample preparation.
9. Microstructural examination of low, medium, high carbon steel and high-speed steel.
10. Microstructural examination of various cast irons in etched and unetched condition.
11. Microstructural examination of Aluminium alloys, copper alloys and Al Metal Matrix Composites.
12. Microstructural examination and hardness measurements of heat-treated steels.
13. Determination of the hardenability of Steels.
14. Scanning Electron Microscope (SEM): analyze tensile and wear tested samples .
15. X-Ray Diffraction (XRD): structure factor and indexing BCC and FCC patterns.
16. Identification of surface defects of the cast and welded samples using the liquid penetrant test.

Fluid Mechanics Lab

MEC303P

Pre-Requisites: None

Course Outcomes:

CO-1	Understanding of basic physics of fluids.
CO-2	Gaining knowledge to calculate and design engineering applications involving fluid.
CO-3	Understanding of analyzing flow systems in terms of mass, momentum, and energy balance.
CO-4	Use of different fluid flow measuring devices.
CO-5	Having knowledge about current research topics about fluid mechanics.

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2					1	1		2	2	1		
CO2	3	3	3	3					1	1		2	2	1		
CO3	2	1	3	1	1				1	1		1	2	1		
CO4	2	1	3	2				1	1	1		1	2	1		
CO5	3	2	3	2	1				1	1		1	2	1		

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

List of Experiments:

1. Calibration of Bourdon pressure gauge with the help of Dead Weight Pressure gauge.
2. To determine the hydrostatic force and center of pressure due to water acting on a partially or fully submerged surface.

3. Determine the meta centric height of a floating body.
4. Verification of Bernoulli's Theorem.
5. Determination of Co efficient of Discharge of Venture-meter
6. Determination of Coefficient of discharge, coefficient of Contraction and co-efficient of velocity of orifice meter.
7. Determination of coefficient of discharge through rectangular notch.
8. Determination of coefficient of discharge through triangular notch.
9. To determine minor losses for flow through pipes.
10. Determination of coefficient of friction of flow through pipes.

Learning Resources:

Text Books:

1. Philip M. Gerhart, John I. Hochstein, Andrew L. Gerhart, "Fundamentals of Fluid Mechanics", 9th Edition, Wiley, 2021

2. Fluid Mechanics Franck .M White Tata Mc GrawHill Publication 2011.

Reference Books:

1. Shames, "Mechanics of Fluids", McGraw Hill Book Co., New Delhi, 1988

2. Streeter V.L., Benjamin Wylie, "Fluid Mechanics", Mc Graw Hill Book Co., New Delhi, 1999

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SCHEME OF INSTRUCTION AND SYLLABUS

For B.Tech. Program in

Mechanical Engineering

(Effective from 2024-25)

DEPARTMENT OF MECHANICAL ENGINEERING

(4th – SEMESTER)

NUMERICAL & STATISTICAL METHODS

BSC401

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Determine the iterative roots of algebraic and transcendental equations and assess the data for the given problem using interpolation and extrapolation.
CO2	Categorize the numerical error involved in Numerical Differentiation and Integration methods
CO3	Analyze the data using statistical methods
CO4	Introduce the concept of Large Sample Distribution
CO5	Perform Testing of Hypothesis for different statistics under sampling theory

Syllabus

Numerical Methods:

Unit 1 **(11 L)**

Numerical Solution of Algebraic and Transcendental Equation:

Method of False Position, Newton Raphson's Method, Fixed Point Iteration Method. Finite Difference, Finite Difference Operators and Their Relations, Interpolation, Newton's Forward and Backward Difference Formulae, Bessel's Formulae. Newton's Divided Difference and Lagrange's Formulae.

Unit 2

Numerical Differentiation and Integration: **(10 L)**

Newton Cote's Quadrature Formulae, Numerical Integration, Trapezoidal Rule, Simpson's 1/3rd and 3/8th Rules. Solution of Ordinary Differential Equations: Taylor's Series, Euler's and Modified Euler's Methods. Runge- Kutta Method of Fourth Order.

Statistical Methods:

Unit 3 **(6L)**

Regression Analysis: Curve- Fitting, Principle of Least Square, Correlation, Coefficient of Correlation and Properties, Rank Correlation. Regression, Linear Regression and Non-linear Regression.

Unit 4 **(15 L)**

Sampling: Population and Random Sample, Sampling Distribution, Test of significance for large samples. Testing of hypothesis, Level of Significance, The Critical and Acceptance region, Two type of errors, Estimate for Population Mean and Variance, Point of Estimation, Confidence Interval for Mean and Variance, Comparison of single mean to a specified value, Comparison of equality of Two Means, Comparison of One variance to a specified value, Comparison of two Variance, Chi-square test, goodness of Fit, t-students and F distribution.

Materials and access:

Textbooks:

- S. S. Sastry, Introductory Methods Of Numerical Analysis, Phi, 4^{th} edition, 2005.
- M. k. Jain, S R K Iyengar and R. L. Jain, Numerical Methods for Scientific Engineering and Computation, Wiley Eastern Limited, 4^{th} Edition, 2003.
- A. M. Goon, M. K. Gupta and B. Dasgupta, Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata, 2002.
- S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, 4^{th} Edition (Reprint), Sultan Chand & Sons, 2008.

Reference Book:

- P. Kandasamy, K. Thilagavathy, K. Gunavathi, Numerical methods, S.Chand & Company, 2nd Edition, Reprint 2012.
- S. M. Ross, "Introduction to probability and statistics for Engineers and Scientists", Elsevier, Academic press, 8th Edition, 2014.
- Miller, Irwin and Miller, Marylees(2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia, 2006.
- A. M. Mood, F. A. Graybill and D. C. Boes: Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd., 2007.
- P. Mukhopadhyay, Applied Statistics, New Central Book Agency,1999.
- B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 42^{nd} Edition.

ME1305 Heat Transfer 3-0-0(3)

Pre-Requisites: None

Course Outcomes:

CO-1	Understand the basic modes of heat transfer
CO-2	Compute temperature distribution in steady-state and unsteady-state heat conduction
CO-3	Estimate heat transfer through forced and free convection
CO-4	Calculate the radiation heat transfer in multi body enclosure
CO-5	Design heat exchangers using LMTD and NTU methods.

CourseArticulationMatrix:

	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-1	2	2	-	3	-	-	-	-	1	-	-	1	2	1
CO-2	2	2	2	3	-	-	-	-	1	-	-	1	2	1
CO-3	-	-	1	3	-	-	-	-	-	-	-	-	2	1
CO-4	2	2	2	3	1	-	-	-	1	-	-	1	2	1
CO-5	2	2	2	3	2	-	-	-	1	-	-	1	2	1

1-Slightly; 2-Moderately; 3-Substantially

Syllabus:

Introduction: Heat Transfer-Different Modes, Governing Laws, Applications to Heat Transfer, Numerical Problems.

General Heat Conduction Equation: Derivation of the equation in (i) Cartesian,(ii) Polarand (iii) Spherical Coordinate Systems.

Steady-state one-dimensional heat conduction: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system, Polar System, and Spherical System with various possible boundary conditions, Thermal Resistances in Series and in Parallel, Numerical Problems.

Critical Thickness of Insulation: Concept, Derivation and Numerical Problems.

Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications, Numerical Problems.

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts: Solutions to various one-dimensional problems using the charts, Numerical problems.

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations - Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Numerical

Problems, Forced convection flow over cylinders and spheres, Internal flows -laminar and turbulent flow

solutions, Numerical Problems.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions, Numerical Problems.

03- Hours

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, View factor algebra, Net radiation exchange in a two-body enclosure, Typical examples for multi-body enclosures, Radiation Shield, Numerical problems.

05- Hours

Heat Exchangers: Definition, Classification, LMTD method, Effectiveness - NTU method, Analytical Methods, Numerical Problems, Chart Solution for Heat Exchanger Problems: Correction Factor Charts and Effectiveness-NTU Charts, Numerical Problems.

05- Hours

Boiling and Condensation: Basics of Pool Boiling, Flow Boiling, Film condensation and dropwise condensation

03- Hours

Learning Resources:

Text Books:

1. Incropera, F. P. and De Witt, D.P. Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York, 8th edition, 2019.
2. Holman, J.P. ,Bhattacharyya Souvik,HeatTransfer,TataMcGrawHill,NewDelhi,10thedition 2017.

Reference Books:

1. M.NecatiOzisik,HeatTransfer-ABasicApproach,McGrawHill,NewYork,1985
2. Alan J. Chapman, Heat Transfer, Macmillan, Pearson Education India; Fourth edition,2016..

KINEMATICS AND DYNAMICS OF MACHINES

MEC402

Course Outcomes:

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

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Classify and solve for mobility of planar mechanisms	Apply
CO02	Perform kinematic analysis of planar mechanisms and synthesizedimensions of linkages.	Analyze
CO03	Construct and analyze cam profiles for the various motions of thefollower.	Create
CO04	Perform static and dynamic force analysis of planar mechanisms.	Analyze
CO05	Create and analyze turning moment diagrams for flywheel design	Analyze
CO06	Analyze and solve static and dynamic balancing of rotating components.	Analyze
CO07	Formulate and solve equations of motion for single degree offreedom vibration systems under free and forced conditions	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2		1							1	2	1		
CO02	3	3	2		1							1	2	1		
CO03	3	3	2		1							1	2	1		
CO04	3	3	2		1							1	2	1		
CO05	3	3	2		1							1	2	1		
CO06	3	3	2		1							1	2	1		
CO07	3	3	2		1							1	2	1		

Syllabus

UNIT-I

Introduction - Basic definitions in kinematics – Mobility - Classification of linkages, kinematic pairs,and mechanisms – Open-loop and closed-loop mechanisms – Gasthof's law – Inversions of four-bar, slider-crank and double-slider mechanisms. [5 hours]

UNIT-II

Analysis of planar mechanisms

Graphical approach for displacement, velocity, and acceleration analyses of planar mechanisms withup to six linkages. Coriolis's component of acceleration – Quick return mechanism. [7 hours]

UNIT-III

Cam design – displacement diagram – standard cam motions – graphical layout of cam profiles – analysis of cam motion – correlation with the motion of inlet and exhaust valves of an IC engine. [6 Hours]

UNIT-IV

Static force analysis – conditions for equilibrium – static force analysis of four bar and slider crank mechanism – effect of friction. [5 Hours]

Dynamic force analysis – Centroid and centre of mass – mass moments and products of inertia – D'Alembert's principle – Principle of superposition. [4 Hours]

Flywheels and Turning moment diagrams – coefficient of fluctuation of speed. [4 Hours]

UNIT-V

Balancing of Rotating Masses – Static unbalance – Dynamic unbalance – Analysis of unbalance - balancing machines. [5 Hours]

Vibration of single degree of freedom systems – undamped and damped free vibrations - natural frequency – logarithmic decrement. Forced vibrations harmonic response – resonance – frequency response plot – magnification factor and phase angle. Support harmonic excitation – vibration isolation. [8 Hours]

Textbooks:

1. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. Theory of Machines and Mechanisms. Vol. 1. New York, NY: Oxford University Press, 2011.
2. Norton, Robert L. Kinematics and Dynamics of Machinery. McGraw-Hill Higher Education, 2011
3. W.T.Thomson, M D Dahleh and C. Padmanabhan. Theory of vibrations with applications. 5th edition. Pearson Education Inc. 2015

Reference Books:

1. Ghosh, Amitabha, and Asok K. Mallik. Theory of Mechanisms and Machines. Affiliated East-West Press Private Limited, 2002.
2. Rattan, S. S. Theory of Machines. Tata McGraw-Hill Education, 2014.

ENGINEERING METALLURGY

MEC403

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	interpret binary phase diagram, describe the micro-constituents in iron-carbon system, Effect of heat treatment and surface hardening on the properties of materials	
CO2	explain different strengthening mechanisms, concepts related to plastic deformation	
CO3	discuss the failure of engineering materials, material testing and characterization techniques	
CO4	classify metals and non-metals for various engineering applications	
CO5	apply advanced materials for specific applications based on their properties and describe computational methods related to materials	

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	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	PSO 3	PSO 4
CO 1	3	1														
CO 2	3	1														
CO 3	1	3														
CO 4		3														
CO 5		3			2											

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Unit-1 - Phase Diagram and Heat Treatment

Solid solutions – Types, factors governing solubility rules. Phase diagram – cooling curve, phase rule, types and interpretation. Iron- carbide (Fe-Fe3C) phase diagram, Microstructural aspects and invariant reactions in Fe-Fe3C diagram. Effect of alloying elements on Fe-Fe3C diagram. TTT and CCT diagrams. Various heat treatment of ferrous and non-ferrous materials and surface hardening process. **(08 hours)**

Unit-2 - Elastic and Plastic Behaviour of Materials

Stress Strain relation in elastic and plastic region, Mechanism of plastic deformation – slip and twinning, Slip systems, critically resolved shear stress, Shear strength of perfect and real crystals. Dislocation – climb, interaction, multiplication and pile ups. Strengthening mechanisms – Solid solution, Grain boundary, Dispersion, Precipitation, Martensite strengthening, Strain aging and Strain hardening. **(08 Hour)**

Unit-3 - Characterization of Materials

Mechanical and microstructural characterization of materials. Structure analysis of material using, OM, XRD, SEM and TEM. Grain size determination. Tensile, hardness, Hardness: Rockwell, Brinell, Vickers hardness, Nano-Indentation Technique, Creep – Creep curve, mechanism of creep deformation. Fatigue - S-N curve, low and high cycle fatigue, stages of fatigue. Failure, Sources of failure, Procedure of failure analysis. Types of fracture in metals, fracture modes, Griffith's theory of brittle fracture, Stress intensity factor, Fracture toughness, Theory of Ductile to brittle transition. **(10 Hour)**

Unit-4 - Properties of Advanced Materials

Properties of plain carbon steel, Tool steel, Stainless steel, Cast iron. Need of microalloying, HSLA steel - Dual phase steel, TRIP steel. Aluminium alloys – classifications, properties, applications, Titanium alloys. Polymers – Types, Properties and applications of PE, PP, PVC. Functionally graded materials. **(08 Hour)**

Unit-5 - Futuristic Materials and Computational Materials Design

Smart materials – Types, Shape memory alloys. Nanomaterials: Carbon nanotubes, Graphene – properties and applications. Metallic foams, Metallic glasses, Super alloys, High entropy alloys, biomaterials, multi-scale materials modelling. Integrated Computational Materials Engineering with application to Industry 4.0. Materials Informatics, Machine learning for design of materials, Property Optimization, property charts, material indices. **(08 Hour)**

Learning Resources

1. Flake.C Campbell, Elements of Metallurgy and Engineering Alloys, ASM International, 2008
2. Dieter.G.E, Mechanical Metallurgy, McGraw Hill, Singapore, 2017
3. Budinski.K.G, Budinski.M.K, Engineering Materials Properties and selection, Edition 9, Pearson Publication, 2010
4. ASM Hand book, Failure analysis and prevention, Vol: 11, 2021
5. Reza Abbaschian, Lara Abbaschian& Robert E. Reed-Hill, Principles of Physical Metallurgy, Cengage Learning, 2013
6. Chaudhery Mustansar Hussain,,"Smart Materials and New Technologies", Springer, 2022.
7. James F. Shackelford et.al. CRC Materials Science and Engineering Handbook, Taylor & Francis, 2015. 8. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction,10th ed., Wiley publication, 2018
9. Donald R. Askeland, Wendelin J. Wright, Essentials of Materials Science & Engineering, 4th ed., Cengage, 2018
10. Raghavan V. Physical Metallurgy: Principles and Practice, PHI Learning, 2015.
11. Shubhabrata Datta and J. Paulo Davim, Machine Learning in Industry, Springer, 2021
12. Shubhabrata Datta and J. Paulo Davim, Materials Design Using Computational Intelligence Techniques, CRC Press, Boca Raton, FL, USA, 2016

Manufacturing Process- II

MEC404

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Understand the chip formation mechanisms, force, and heat transfer models in different machining processes.
CO2	Develop experimental procedures to validate the empirical and analytical models in machining
CO3	Select suitable cutting tool material and process parameters to maximize the material removal rate, tool life, and surface finish.
CO4	Develop process plans for machining components in conventional, CNC, and advanced machining processes and conduct machinability studies.
CO5	Develop a CNC part program for the given component drawing and perform machining operations in CNC machining / turning centers
CO6	Follow safety rules and standard codes of practice during machining.

Course Articulation Matrix:

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	1	1				1		1	1		1	2		2	
CO 2	3	1	2	1			1		1	1		1	2		2	
CO 3	3	1	2	1			1		1	1		1	2		2	
CO 4	3	1	2	1			1		1	1		1	2		2	
CO 5	3	1	3				1		1	1		1	2		2	
CO 6						1	1	1	1	1		1				

Course Objectives

The course will enable the students to

- Mechanism of material removal and forces during machining, the influence of tool geometry in machining, tool materials, and tool wear mechanisms

- Conventional machining processes, machine tools, and their process capabilities, the influence of process parameters on machining (cutting force, tool wear, and surface finish)

- Preparation of process plan and product cost estimation for the given component

- Principles and applications of advanced machining processes

- CNC programming for turning and machining centers

Syllabus

Unit 1

Theory of metal cutting: Types of metal cutting processes, Orthogonal and Oblique cutting, cutting tool nomenclature, Mechanism of chip formation – shear deformation and shear plane, the effect of machining parameters on chip reduction coefficient, Forces and temperature in metal cutting, Merchant's Force Circle, Tool wear -types, mechanisms, Tool life - Machinability and surface finish, cutting tool materials and cutting fluids, Economics of Machining. [15 Hours]

Unit 2

Conventional Machining Processes- Turning, milling, shaping, slotting – machines- types of operations, tool geometry, material removal mechanisms, the influence of process parameters on MRR and Tool Life, process plan and process capability, finishing processes: Grinding – abrasives, operations, and super finishing processes, product cost estimation. [15 Hours]

Unit 3

Advanced Machining Processes: Introduction to Computer Numerical Control Machines (CNC) – features and construction, Micro Machining, Electrical Discharge Machining, Wire EDM, ElectroChemical Machining, Laser Beam, Plasma Arc Machining, and High-Speed Machining, Metrology for micromachined components. [15 Hours]

Text Books:

1. Amitabha Ghosh and A.K. Mallick, Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.

Reference Books:

1. SeropeKalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2023 - 8th Edition in SI Units

2. P. M. Agrawal, V. J. Patel, 'CNC Fundamentals and Programming', Charotar Publishing House Pvt. Ltd, 2nd Edition-2017.

3. V. K. Jain, Micro manufacturing, CRC press, 2012.

4. Joseph McGeough, Micromachining of Engineering materials, Marcel Dekker Publishers, New York,2002.

Manufacturing Process II LAB

MEC404P

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

Course Articulation Matrix:

	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														
CO 2														
CO 3														
CO 4														
CO 5														

Lab Exercises:

- Preparation of process plan for machining of a given component.
- Machining practice: Study and practice various metal cutting operations in Lathe, Milling, Drilling, and Grinding machines.
- Validating analytical and empirical metal cutting models using an experimental procedure
- CNC Programming and Practice – Turning Centre and Milling

- Laser Cutting: Sample Preparation Exercises
- Cutting force measurement: Using tool dynamometers to measure cutting forces in turning, milling, and drilling processes.
- Group Project: Process planning, Tool life studies, selection of optimum machining conditions for MRR and Surface finish criteria, and manufacture & assembly of the products as per the given drawing using the machines available in the workshop. [15 Hours]

Heat Transfer Lab

MEC401P

Pre-Requisites: **None**

Course Outcomes:

CO-1	Estimate heat transfer coefficient of air in Free and forced convection modes and comparewith theoretical and empirical values.
CO-2	Estimate the efficiency and effectiveness of a pin-fin, heat exchanger and equivalent thermalresistance of a composite slab.
CO-3	Demonstration and performance evaluation of heat pipe, thermal radiation principles andtwo-phase heat transfer phenomenon.
CO-4	Analyse the performance of solar collectors.
CO-5	Demonstration and performance evaluation of fuel cells.

Course Articulation Matrix:

	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-1	2	2	-	3	-	-	-	-	1	-	-	1	2	1
CO-2	2	2	2	3	-	-	-	-	1	-	-	1	2	1
CO-3	-	-	1	3	-	-	-	-	-	-	-	-	2	1
CO-4	2	2	2	3	1	-	-	-	1	-	-	1	2	1
CO-5	2	2	2	3	2	-	-	-	1	-	-	1	2	1

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

List of Experiments:

1. **Forced Convection Apparatus:** Determination of theoretical, experimental and empirical valuesof forced convection heat transfer coefficient for flow through a circular pipe.
2. **Natural Convection Apparatus:** Determination of experimental and empirical values of free convection heat transfer coefficient from a Heated Vertical Cylinder.
3. **Pin-Fin Apparatus:** Determination of temperature distribution, efficiency and effectiveness of apin fin working in a forced convection environment.
4. **Composite Slab Apparatus:** Determination of theoretical and experimental values of equivalent thermal resistance of a composite slab.
5. **Heat Pipe Demonstrator:** Demonstration of isothermal characteristics exhibited by a heat pipe in comparison to other pipes.
6. **Parallel and Counter flow Heat Exchanger:** Determination of LMTD of parallel and counter flowheat exchanger.
7. **Emissivity Apparatus:** Determination of the surface emissivity of a given test plate at a given absolute temperature.
8. **Stefan-Boltzmann Apparatus:** Determination of the Stefan-Boltzmann constant and comparisonwith the theoretical value

9. **Film Boiling and Condensation Apparatus:** Determination of the heat transfer coefficient infilm boiling and condensation.
10. **Solar flat plate collector:** Performance evaluation of solar flat plate collector in natural and forced circulation modes.
11. **Parabolic concentric solar collector:** Performance evaluation of parabolic concentric solar collector.
12. **Solar PV Module:** Identifying and measuring the parameters of a solar PV Module in the field.
13. **Solar Simulator:** Dark and Illuminated Current-Voltage characteristics of solar cell.
14. **Fuel Cells:** Performance evaluation of DMFC and PEM fuel cells.

Learning Resources:

Text Books:

1. M. Necati Ozisik, Heat Transfer - A Basic Approach, McGraw Hill, New York., 1985
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley andSons, New York, 8th Edition, 2019.
3. Frano Barbir, PEM Fuel Cells-Theory and Practice, Elsevier Academic Press, 2005, 2nd Edition.

Reference Books:

1. Holman, J. P., Bhattacharyya Souvik, Heat Transfer, Tata McGraw Hill, New Delhi, 10th edition2017
2. Sukhatme, S. P. and Nayak, J. K., Solar Energy, McGraw Hill Education, 2017, 4th Edition.
3. Holman, J., Experimental Methods for Engineers, McGraw Hill Education, 2017, 7th Edition.

Online Resources:

1. Solar Energy Laboratory, IIT Roorkee, https://www.iitr.ac.in/departments/HRE/pages/Facilities+Solar_Energy_Laboratory.html

KINEMATICS AND DYNAMICS LABORATORY

MEC402P

Course Outcomes:

At the end of the course, the student shall be able to:

CO1	Model and analyze planar mechanisms using software package	Analyze
CO2	Create an assembly and demonstrate the various mechanism using the Tool kit	Apply
CO3	Determine the natural frequency, damping, critical speeds in translational and rotating dynamical systems	Analyze
CO4	Analyze free and forced vibration of single and two degree of freedom dynamical system with and without damping	Analyze
CO5	Determine moment of inertia and center of gravity of complex objects	Evaluate
CO6	Construct the characteristic plots for different types of governors	Evaluate
CO7	Evaluate the working of a gyroscope and measure the gyroscopic couple	Evaluate
CO8	Analyze and implement the balancing of rotating and reciprocating masses	Analyze

Course Articulation Matrix:

CO-PO Mapping: [affinity# : 3 – high; 2- moderate; 1- slightly]

	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO 1	3	3	2	1	2				1	2		1	2	1		
CO 2	3	3	2	1	2				1	2		1	3	1		
CO 3	3	2	2	1	2				1	2		1	2	1		
CO 4	3	2	2	1	2				1	2		1	2	1		
CO 5	3	2	2	1	2				1	2		1	2	1		
CO 6	3	2	2	1	2				1	2		1	2	1		

CO 7	3	2	2	1	2				1	2		1	2	1		
CO 8	3	3	2	1	2				1	2		1	2	1		

List of Equipment required for meeting the COs

a) Kinematics

- Kinematic analysis using software package
- Kinematic Tool kit

b) Dynamics

- Undamped and damped free vibration
- Damped forced vibration
- Torsional free vibration
- Free and forced vibration of equivalent spring mass system
- Radius of gyration of a compound pendulum
- Moment of inertia of a connecting rod
- Gyroscope
- Whirling of a shaft
- Different types of governors
- Balancing of rotating mass
- Balancing of reciprocating mass
- Dunkerley's setup

List of Exercises.

1. Modelling and analysis of slider crank and four bar mechanism and its inversions
2. Modelling and analysis of six bar chains
3. Modelling and analysis of crank and slotted lever and Whitworth quick return mechanism
4. Modelling and analysis of cam mechanism
5 .Modelling and analysis of practical mechanisms and demonstration of mechanism using the kinematic Tool kit
6 .Undamped and damped free vibration of a translational system
7. Undamped and damped free vibration of a rotational system
8. Undamped free vibration of two degree of freedom spring mass system
9. Undamped and damped forced vibration of equivalent spring mass system
10. Determination of radius of gyration of a compound pendulum and determination of moment of inertia of a connecting rod
11. Demonstration of whirling of a shaft and study of governors
12. Verification of a Dunkerley's rule and study of Gyroscope
13. Balancing of rotating mass CO08 14 Balancing of reciprocating mass