Jharkhand University of Technology, Ranchi
B.Tech. (Mechanical Engineering)

Semester-IV

S.No.	Course Code	Course Title	Hours per week				Cr	FM	Overall Pass Marks	Internal (CIE)	External (SEE)		Categorization
			L	T	P	J					FM	PM	
01	BSC401	Numerical & Statistical Methods	3	1	0		4	100	100	35	30	70	BSC
02	MEC401	Heat Transfer	3	0	0		3	100	100	35	30	70	MEC
03	MEC402	Kinematics and Dynamics of Machines	3	0	0		3	100	100	35	30	70	MEC
04	MEC403	Engineering Metallurgy	3	0	0		3	100	100	35	30	70	MEC
05	MEC404	Manufacturing Process- II	3	0	0		3	100	100	35	30	70	MEC
Total			**15**	**1**	**0**		**16**	**500**	--	--	--		--
Practical			**L**	**T**	**P**		**Cr**	**FM**	**Overall Pass Marks**	**Internal**	**External**		**Categorization**
											FM	**PM**	
06	MEC401P	Heat Transfer Lab	0	0	2		1	50	25	30	20	10	MEC
07	MEC402P	Kinematics and Dynamics of Machines Lab	0	0	2	6	1	50	25	30	20	10	MEC
08	MEC404P	Manufacturing Process-II Lab	0	0	2		1	50	25	30	20	10	MEC
Total			**0**	**0**	**6**		**3**	**150**	--	--	--		--
Audit Course			**L**	**T**	**P**		**Cr**	**FM**	**Overall Pass Marks**	**Internal**	**External**		**Categorization**
											FM	**PM**	
09	AUC401	Mastering Personal Finance (Basic to Advance Strategies)	3	0	0		--	100	35	30	70	21	AUC
10	AUC402P	Sports/NCC/NSS/YOGA/Painting/ Music/Classical Dance	6				Student shall participate actively in one of the activities and for Passing of the semester "Participation Certificate" in activity will be mandatory. Student participation shall be monitored and participation record shall be maintained at institute level.						
11	INT401P	Summer Internship	6-8 Weeks				2	--	--	1/0	--		INT
Total			**3**	**0**	**0**		**2**	**100**	--	--	--		--
Grand Total			**18**	**1**	**6**	**6**	**21**	**750**	--	--	--		--

Note-

1. **MEC- Mechanical; AUC- Audit Course; L: Lecture, T: Tutorial, P: Practice, CIE- Continuous Internal Evaluation, SEE- Semester End Evaluation.**
2. **INT- Internship (Completion of internship will be marked as-1; Non-completion of internship will be marked as-0 by the institution; The submitted write up & presentation record shall be kept safely by the institution).**
3. **J- Self learning hours shall not be reflected in the Time table. Self-learning includes micro project/ assignment/ other activities as mentioned in earlier semester.**

(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, 4th edition, 2005.
- M. k. Jain, S R K Iyengar and R. L. Jain, Numerical Methods for Scientific Engineering and Computation, Wiley Eastern Limited, 4th 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, 4th 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, 42nd 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	PO 10	PO 11	PO 12	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	PO10	PO11	PO12	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