

Programme Structure and Syllabi for B. Tech. Mechanical Engineering (2023 batch onwards)



**Department of Mechanical Engineering
Punjab Engineering College
(Deemed to be University) Chandigarh, India**

Mechanical Engineering

Semester Scheme B.Tech. 3rd To 8th SEMESTER

2023-24 ONWARDS

Semester I

Course Name	Course Code	L	T	P	Credits
Orientation	OR2301	-	-	-	1
Introduction to Mechanical Engineering	OR2302	1	0	0	1
Calculus	MA2301	3	0	2	4
Applied Chemistry-II	CH2302	3	0	2	4
Universal Human Values	GS2302	1	0	0	1
Engineering Drawing with CAD software	ES2302	2	0	4	4
Skill Development Workshop	ES2303	0	0	4	2
Introduction to Product Design	ES2307	0	0	4	2
Introduction to Mechatronics	ES2304	3	0	2	4
Total					23

Semester II

Course Name	Course Code	L	T	P	Credits
Linear Algebra, Differential Equations and Vector Calculus	MA2302	3	0	2	4
Mechanics and Optics	PY2302	3	0	2	4
Introduction to Computer Programming	ES2301	3	0	2	4
Introduction to Environmental Sciences	GS2301	1	0	0	1
Communication Skills	HS2351	2	0	2	3
Strength of Materials	ES2306	3	0	2	4
Total					20

Semester-III

Course Name	Course Code	L	T	P	Credits
Elements of Manufacturing Processes	MEN3001	3	0	2	4
Elements of Thermodynamics	MEN3002	3	1	0	4
Mechanics of Materials	MEN3003	2	1	0	3
Kinematics of Machines	MEN3004	2	1	0	3
Physical Metallurgy and Heat Treatment	MEN3005	3	0	0	3
Fluid Mechanics	MEN3006	2	1/2	2/2	3
Total					20

Semester-IV

Course Name	Course Code	L	T	P	Credits
HSM-II					3
Manufacturing Processes	MEN4001	3	0	2	4
Applied Thermodynamics	MEN4002	3	0	2	4
Refrigeration and Air Conditioning	MEN4003	3	1	0	4
Mechanical Vibrations	MEN4004	3	1/2	2/2	4
Dynamics of Machines	MEN4005	3	1/2	2/2	4
Total					23

Semester-V

Course Name	Course Code	L	T	P	Credits
Production and Operations Management	MEN5001	3	0	0	3
Heat and Mass Transfer	MEN5002	3	0	2	4
Design of Mechanical Systems	MEN5003	3	0	0	3
Mechanical Measurements and Control	MEN5004	3	0	0	3
CAD/CAM	MEN5005	3	0	0	3
Minor Project	MEP5101	0	0	8	4
Total					20

Semester-VI

Course Name	Course Code	L	T	P	Credits
Internship Training Part-I	MEN6001	0	0	12	6
Internship Training Part-II	MEN6002	0	0	4	2
Internship Training Part-III	MEN6003	0	0	8	4
Or					
Optional Course work					
Deptt. Elective Course-V		3	1	0	4
Open Elective	MEO1001	3	1	0	4
Project Work	MEP6001	0	0	8	4
Total					12

Semester-VII

Course Name	Course Code	L	T	P	Credits
HSM-IV					3
Deptt. Elective Course-I		3	1	0	4
Deptt. Elective Course-II					4
Open Elective-I	MEO1002	3	1	0	4
Open Elective-II	MEO1004	3	0	2	4
Major Project-I	MEP7001	0	0	8	4
Total					23

Semester-VIII

Course Name	Course Code	L	T	P	Credits
HSM-III					3
Deptt. Elective Course-III					4
Deptt. Elective Course-IV					4
Open Elective-III	MEO1003	3	1	0	4
Proficiency					2
Major Project-II	MEP8001	0	0	8	4
Total					21

Minor Specialization in Sustainable Thermal Management

Course Name	Course Code	L	T	P	Credits
Design of Thermal Systems	MEM1001	3	1	0	4
Thermal System Modelling and Simulation	MEM1002	3	1/2	1/2	4
Computational Fluid Dynamics	MEM1003	3	0	2	4
Minor Specialization Project-I	MEM1004	0	0	6	3
Minor Specialization Project-II	MEM1005	0	0	6	3
Total					18

Open Electives to be offered by Mechanical Engineering Department

	Course Name	Course Code	L	T	P	Credits
Open Elective (6 th Semester)	Work Station Design and Neuro-Ergonomics	MEO1001	3	1	0	4
Open Elective I	Hydraulic and Pneumatic Control Design	MEO1002	3	1	0	4
Open Elective II	Automotive Engineering	MEO1004	3	0	2	4
Open Elective III	CAD/CAM	MEO1003	3	1	0	4

Department Elective I

Course Name	Course code	L	T	P	Credits
Optimization Techniques in Engineering	MEE1001	3	1	0	4
Computer Integrated Design and Manufacturing	MEE1002	3	1	0	4
Mechanisms and Machines	MEE1003	3	1	0	4
Vibration and Noise Control	MEE1004	3	1	0	4
Production Engineering	MEE1005	3	1	0	4
Convective Heat and Mass transfer	MEE1006	3	1	0	4
Internal Combustion Engines	MEE1007	3	1	0	4
Power Plant Engineering	MEE1027	3	1	0	4

Department Elective II					
Course Name	Course code	L	T	P	Credits
Total Quality Management	MEE1008	3	1	0	4
Fracture mechanics and fatigue	MEE1009	3	1	0	4
Modelling and Simulation	MEE1010	3	1	0	4
Kinematics and dynamics of robots	MEE1011	3	0	2	4
Precision Engineering	MEE1012	3	0	2	4
Automotive combustion and emissions	MEE1013	3	1	0	4
Computational fluid dynamics	MEE1014	3	0	2	4
Industrial Automation	MEE1028	3	0	2	4
Department Elective III					
Course Name	Course code	L	T	P	Credits
Finite element method in Engineering	MEE1015	3	0	2	4
Hydraulic and Pneumatic Control Design	MEE1016	3	1	0	4
Automotive Engineering	MEE1017	3	0	2	4
Work Station Design and Neuro-Ergonomics	MEE1018	3	1	0	4
Experimental Stress analysis	MEE1019	3	1/2	2/2	4
Mechanics of Composites materials	MEE1020	3	1	0	4
Production planning and control	MEE1021	3	1	0	4
Composite Materials	MEE1022	3	0	2	4
Hydraulic Machines	MEE1023	3	1/2	2/2	4
Design of Thermal systems	MEE1024	3	1	0	4
MEMS and Micro System Design	MEE1025	3	1	0	4
Tribology & Lubrication	MEE1026	3	1	0	4
Department Elective IV					
Course Name	Course code	L	T	P	Credits
Vehicle Dynamics	MEE1029	3	0	2	4
Advanced Manufacturing Techniques	MEE1030	3	1	0	4
Surface Engineering	MEE1031	3	0	2	4
Product Design and Development	MEE1032	3	1	0	4
Two Phase Flow Heat Transfer	MEE1033	3	1	0	4
Thermal System Modelling and Simulation	MEE1034	3	1/2	2/2	4
Non-Conventional Energy Resources	MEE1035	3	1	0	4
Experimental Methods for Engineers	MEE1036	3	1	0	4
Micro-nano Scale Heat Transfer	MEE1037	3	0	2	4

Department Elective V					
Course Name	Course code	L	T	P	Credits
Principles of Product Design	MEE1038	3	1	0	4
Industrial Engineering and management	MEE1039	3	1	0	4
Reliability and Maintenance Engineering	MEE1040	3	1	0	4
Operation Research and Simulation Techniques	MEE1041	3	1	0	4

NAME OF DEPTT : **Department of Chemistry**
 Course name : Applied Chemistry I (CSE, ECE, EE, DS, VLSI, AI)
 Course Code : CH2301
 Year : 23-24 (2nd semester)
 Credits : 4
 L T P : 3 0 2

Total No. of Lecture-42

Objective: To teach the fundamentals and applications of Chemical Sciences essential for the development of electrical and electronic materials and technologies. Students will be learning various analytical techniques for the characterizations of electronic organic/inorganic materials.

<i>Lecture wise breakup</i>		<i>No. of Lectures = 42</i>
1	Fundamentals for Applied Chemistry Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections, Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir–Hinselwood Mechanism, acid-base equilibria in non aqueous media, Introduction to Computational chemistry and open source softwares	(10)
2	Polymeric Materials Mechanism and methods of polymerization, structure-activity relationship, Conducting Polymers: types (n- or p- doping) and applications, Polymeric fibre materials	(6)
3	Spectroscopic Methods for structural Analysis: Principle and applications (UV, IR, NMR, SEM and TEM)	(9)
4	Energy Storage and Sensing Devices: Fundamentals of Electrochemistry, types of electrodes, Reference electrodes, Ion-selective electrodes, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Renewable energy (Artificial photosynthesis), Solar cells, Sensors for IoT	(8)
5	Chemistry of Electronic and Electrical Materials Semi-conductor and super conducting Materials, Carbon materials, Optical Materials (OLED), 2D Materials, Magnetic materials.	(9)

- Outcomes:**
1. To be able to apply the fundamentals of chemistry towards developing new Technologies based on new materials.
 2. To attain the essential analytical skills and designing of materials for electrical and electronic applications.
 3. Application of software as important tools in technological applications.

Books:

1. Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2. Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3. Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman& Co).
4. Atkin’s Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).
5. Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6. D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition,(Thomson learning, Indian Edition).
7. Computational chemistry: Introduction to theory and applications of molecular and quantum mechanics: Lewars Errol G. (Springer)
8. NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Practicals	
Sr. No.	Name of Experiment
1.	To find the strength of the given sodium hydroxide solution by titrating it against standard solution of hydrochloric acid using pH meter.
2.	To determine the ferrous content in the supplied sample of iron ore by titrimetic analysis against standard $K_2Cr_2O_7$ solution using potassium ferricyanide $[K_3Fe(CN)_6]$ as external indicator.
3.	To find the strength of Sodium hydroxide (NaOH) solution by titrating it against 0.1 N hydrochloric acid conductometrically.
4.	Determination of reaction rate constant of acid catalyzed Hydrolysis of Ester.
5.	Verify Beer-Lambert's law for $KMnO_4$ colorimetrically.
6.	Synthesis of Polyaniline based conducting polymer.
7.	To determine the value of rate constant (k) for the inversion of sucrose by polarimeter.
8.	To prepare nickel dimethyl glyoxime complex, $[Ni(DMG)_2]$. Illustrate the structure of the complex using FTIR.
9.	Synthesis of iron oxide nanoparticles and characterization using FTIR.
10.	Predicting the best Molecular docking conformations of a protein with the help of Swiss Dock.

NAME OF DEPTT.	:	Department of Chemistry	
Course name	:	Applied Chemistry II (Mech.,Prod.,Metta,Aero.,Civil Engg.)	
Course Code	:	CH2302	
Year	:	23-24 (1 st semester)	
Credits	:	4	
L T P	:	3 0 2	Total No. of Lecture-42

Objective: To teach the fundamentals and applications of Chemical Sciences essential for the development of engineering materials and processing technologies. Students will be learning various analytical techniques for the characterizations of composites and hybrid materials.

Lecture wise breakup		No. of Lectures = 42
1	Fundamentals for Applied Chemistry Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections , Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir –Hinshelwood Mechanism, Acid -base equilibria in non aqueous media	(8)
2	Polymer Chemistry Mechanism and methods of polymerization, Structure-Activity relationship, High performance polymers and applications, Natural and synthetic fibers, biodegradable polymers	(5)
3	Fuels and Catalysis Petroleum processing, Solid and liquid Fuels for Propellants, Chemistry of combustion and equations, Catalytic convertors	(5)
4	Electrochemistry and Corrosion: Introduction to Electrochemistry, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Corrosion control and protective coatings	(7)
5	Spectroscopic Methods for structural analysis: Principle and Applications (UV, IR, NMR, AAS/ICP-AES, SEM, TEM, XRD).	(10)
6	Chemistry of Engineering Materials Ceramic and Cement Materials, Metals and Alloys ,Phase change materials, Bio-inspired materials, Composite materials, Smart materials: Chemical compositions and its applications	(7)

Outcomes:

1. To be able to apply the fundamentals of chemistry towards emerging materials to benefit the societal needs.
2. To attain the essential analytical skills and designing of materials for various applications.
3. To be able to identify the chemical compositions required for designing of high performance materials.

Books:

1. Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2. Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3. Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman & Co).
4. Atkin’s Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).

5. Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6. D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition, (Thomson learning, Indian Edition).
7. NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Practicals	
Sr. No.	Name of Experiment
1.	Measurement of acid base equilibria by pH meter in water sample.
2.	To determine the ferrous content in the supplied sample of iron ore by titrimetric analysis against standard K ₂ Cr ₂ O ₇ solution using potassium ferricyanide [K ₃ Fe(CN) ₆] as external indicator.
3.	Synthesis of polyaniline based conducting polymer.
4.	To find the strength of given NaOH solution by titrating it against 0.05 N Hydrochloric acid solution using a conductivity meter.
5.	Synthesis of iron oxide nanoparticles and characterization using various techniques (UV/ FTIR/ SEM/XRD).
6.	To determine the value of rate constant (k) for the inversion of sucrose by polarimeter.
7.	To verify Lambert Beer's law for KMnO ₄ using UV-Visible Spectrophotometer.
8.	To determine the percentage of Cu in the copper alloy solution provided 0.1 N hypo solution.
9.	To prepare nickel dimethyl glyoxime complex, [Ni(DMG) ₂]. Illustrate the structure of compound using FTIR.
10.	Determination of reaction rate constant of acid catalyzed hydrolysis of ester.

Course Name	:	Introduction to Computer Programming
Course Code	:	ES 2301
Credits	:	4
L T P	:	3 0 2

Course Objectives:
<ul style="list-style-type: none"> To develop logical skills so that students should be able to solve basic programming problems To use programming knowledge to develop small projects including basic GUI design

Total No. of Lectures: 42

Lecture wise Breakup		No. of Lectures
Unit 1	INTRODUCTION TO PROGRAMMING Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application softwares like editor. Flowcharts. Algorithm, specification of algorithm. Industrial uses of programming in various domains	3
Unit 2	DATA TYPES and OPERATORS AND EXPRESSION Storing integers, numbers with decimals, characters and strings, typecasting. User input and output, use of command line arguments Operators: arithmetic operators, relational operators, logical operators, bitwise operators, miscellaneous operators. Expressions and their evaluation. Precedence and associativity rules.	7
Unit 3	ITERABLE CONTAINERS and STATEMENTS List, set, tuple and dictionaries; range function; difference between various iterable containers Decision making statements: if, if-else, nested if and if-else. Control statements: for & while loops, nested loops; Role of statements like break, continue	7
Unit 4	FUNCTIONS and CLASSES Advantage of modularizing program into functions, function definition and function invocation. Function arguments: default, keyword and positional arguments. Scope and lifetime of a variable. Recurrence relations and Recursion Advantage of using classes, defining class data members & functions and accessing using objects. Constructors and destructors in a class, parameterized constructors.	8

Unit 5	GUI design Introduction to tkinter library, use of TK & mainloop methods, use of widgets like Button, Canvas, Checkbutton, Entry, Frame, MenuButton, Listbox, Menu, Scrollbar, Text, Message, Pack, Grid, place etc. for GUI design.	5
Unit 6	SORTING AND SEARCHING Searching: Linear search, binary search and hash search. Sorting: Insertion sort, selection sort, bubble sort, quick sort, merge sort, heap sort, and Bucket sort. Time and space complexity of algorithms, comparing algorithms	9
Unit 7	Problem Solving Real-world programming problems	3

Total No. of Turns: 14

List of Experiments		Number of Turns
1	Implement programs to input/output various data types	2
2	Implement programs to use command line arguments and operators	2
3	Implement programs making use of conditional statements and loops	2
4	Implement programs making use of iterable containers	2
5	Implement programs making use of functions and recursion	2
6	Implement various searching and sorting algorithms	2
7	Project work including GUI design using tkinter	2

Course Outcomes: At the end of the course, students will be able to:	
1	Develop understanding of the fundamental concepts essential for programming.
2	Make efficient use of iterables, function and classes to programming problems
3	Develop simple GUI applications
4	Learn to compare algorithms and improve efficiency of algorithms

Text Book:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Python Programming: An Introduction to Computer Science by John M. Zelle, Franklin, Beedle& Associates Inc	Latest Edition
Reference Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Think Python, How to Think Like a Computer Scientist, Version 2.0.17, Allen Downey Green Tea Press Needham, Massachusetts	Latest Edition
2.	Core python programming, Dr. R. Nageswara Rao, 2nd edition,	Latest

	Dreamtech press	Edition
--	-----------------	---------

Equivalent MOOCs courses:

Sr. No.	Course Links	Offered by
1.	Programming, Data Structures and Algorithms using Python, https://nptel.ac.in/courses/106106145	NPTEL
2.	Programming in Python, https://onlinecourses.swayam2.ac.in/cec22_cs20/preview	Swayam

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and 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
CO1	3	1	2	1	3	1	-	1	-	1	-	1	2	-	-
CO2	3	2	2	2	3	1	-	1	-	1	-	1	2	-	-
CO3	3	2	3	1	3	1	-	1	1	1	1	-	1	-	-
CO4	3	2	2	3	2	1	-	1	-	-	-	1	1	-	-

1: Low, 2: Medium, 3: High

Course Name	Strength of Materials
Course Code	ES2306
Credits	4
L T P	3-0-2

Course Objectives:

At the end of this course, the student should be able to understand the basic concept regarding the strength of material. The course will prepare the students to apply these concepts to engineering and applied sciences problems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Equations of static equilibrium, Concept of various forces/loads, stresses and strains developed due to these forces/loads, Uniaxial tensile test, Stress-strain diagrams for various types of ferrous and non-ferrous materials, isotropic and anisotropic materials, Compression test, impact test, fatigue test, hardness test, torsion and bending test as per ASTM standards	4
2	SIMPLE STRESS & STRAIN: Hooke's law, stress and elongation produced in various types of bars due to its own weight and applied axial force, Poisson's ratio, and relationship between elastic constants, stresses and elongation produced in simple & composite bars due to axial, thermal and combined loading.	6
3	2-D STATE OF STRESS ANALYSIS: Generalized 2-D state of stress accompanied by shear stress, stresses on an arbitrary plane under this state of stress, sign conventions for normal and shear stresses, complementary shear stress, principal stresses and principal planes, Different stresses determination through Mohr's stress circle approach in 2-D generalized state of stress.	6
4	SHEAR FORCE AND BENDING MOMENT IN BEAMS: Classification of beams, supports and loads, Shear force (SF) & Bending moment (BM) in beams and their sign conventions, Relation between rate of loading (w) with SF and BM. SF and BM diagrams of cantilevers, simply supported beams with or without overhang under different types of loading e.g. concentrate loads, uniformly distributed load, uniformly varying load, moment or its combinations, the point of contra-flexure	6
5	BENDING & SHEAR STRESSES IN BEAMS: Theory of pure bending, position of neutral axis, Bending equation, practical application of bending equation, review of moment of area concepts, variation of bending stress in various cross-sectional beams, shear stresses in beams, variation of shear stresses for different cross-sectional beams	6
6	TORSION OF CIRCULAR SHAFTS: Torsional equation of circular shafts, shear stress distribution, torsional rigidity, power transmitted by the shaft, comparisons of hollow & solid circular shafts, analysis of shafts in series and parallel mode, Equivalent bending moment and equivalent torque for a shaft subjected to bending moment and torque simultaneously	5
7	COLUMN AND STRUTS: Definitions, Euler's theory of columns buckling, Euler's equation for various end restraints, Rankine and other empirical formulae.	4
8	DEFLECTION OF BEAMS: Relationship between bending moment, slope and deflection, moment area method, method of integration, Macaulay's method, Use of these methods to determine slope and deflection for statically determinate and statically indeterminate beams under various loading conditions.	5

Sr. No.	List of Experiments	No. of Turns
1	To perform uni-axial Tensile Test on a given material and to determine its various mechanical properties under the uni-axial tensile loading.	2
2	To perform uni-axial compressive test on a given material and to determine its various mechanical properties under the uni-axial compression loading.	2
3	To perform shear test on a given material and to determine its shear stress of the material.	2
4	To perform torsion test on a given material and to determine its various mechanical properties under torsional load.	2
5	To perform Column test of a given material and to determine its Euler's buckling load and Young's modulus of elasticity of the material.	2
6	To perform Impact test on a given material and to determine its resilience.	2
7	To perform a test on close and open coil springs under axial loading on spring tester and determine its various mechanical properties.	2
8	To study and perform Fatigue test on a given material and to determine endurance strength and limit of the material.	2
9	To determine various Rockwell hardness of the given materials	2
10	To perform the Three point bending test on a given material and determine its Young's modulus of elasticity and bending strength.	2
11	To study the concepts of various strain gauges along with their areas of applications	2
12	To study the Creep test on the given material specimen and determine its creep strength.	2
13	To perform the various tests on the given wooden specimens by wood UTM and determine its various strengths.	2
14	To perform test on strain hardened specimen and to determine its effect on the Young's modulus of elasticity.	2

Course Outcomes: By the end of this course, the student will be able to:

1	Understand the concept of stresses & strains, various types of materials, its properties & testing processes as per ASTM standards.
2	Understand elastic constants and also be able to determine stresses & elongations in simple and composite bars under various types of loads.
3	Determine stresses on an arbitrary plane for a generalized 2-D state of stress accompanied by shear stress through analytical and graphical methods
4	Understand and be able draw shear force and bending moment diagrams for different types of beams under various types of loading.
5	Understand bending and shear stress equations and its application in determination of bending & shear stresses in different cross-sectional beams at any point across its length.
6	Understand the torsional stresses for solid, hollow and composite circular shafts and its importance in power transmission.
7	Understand the Column and struts and determine the buckling load under various axial loadings.
8	Determine the deflections of various beams subjected to different loading by various methods.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Strength of Material - G. H. Ryder (MacMillan)	1969
2	An Introduction to the Mechanics of Solids – Crandall & Dahl (Mc-Graw Hill)	2012
3	Engg. Mechanics of Solids - E. P. Popav (Pearson Education)	2003
4	Strength of Material - D S Bedi, Fifth Ed.	2010
5	Strength of Material - R K Rajput, Fifth Ed.	2012

Course Name	Engineering Drawing with CAD Software	
Course Code	ES2302	
Credits	3	
L TP	2-0-2	
Course Objectives:		
At the end of this course, the student should be able to understand the basic concepts of Engineering Drawing. The student should be able to visualize and draw the two- and three-dimensional objects. The student should also be able to understand the features associated with operations of the computer-aided design (CAD) software.		
Total No. of Lectures – 28		
Lecture wise breakup		Number of Lectures
1	Introduction to Engineering Graphics, Concept of points and lines, System of Projections, Orthographic projections, Dimensioning.	4
2	Introduction to different types of CAD Softwares e.g. SolidWorks/AutoCAD/CATIA etc., 2D-Sketching, Sketching Entities & Relation, 3D-Sketching, Editing and its Features, Dimensions, Sketch Tools, File handling.	7
3	Projections of planes / lamina on reference planes, classification of primary and secondary planes, use of auxiliary planes, Exercises using CAD software.	5
4	Classification of solids, Projections of solids on the basis of positions of the axis of various solids on reference planes and Sectioning of solids, Exercises using CAD software.	6
5	Introduction to Perspective projection, isometric views, Isometric lines & Axes, conversion of orthographic views to isometric views and vice-versa, Exercises using CAD software.	6
List of Experiments:		Number of Turns
Exercises to be done using CAD software		
1	2D & 3D Sketching using various sketching tools.	2
2	Projection of planes.	2
3	Developments of 3D-parts.	2
4	Projection of solids.	2
5	Projection of Sectioning of solids.	2
6	Isometric and orthographic views.	2
7	Generating drawings of 3D-parts.	2

Sr. No.	Course outcome	Knowledge Level (Blooms Level)
	By the end of this course, the students will be able to:	
1	Understand the basic concepts of Engineering Graphics, drawing standards, conventions and symbols that are in common usage.	L2
2	Apply the concepts of engineering drawing to create orthographic projections of points, lines, planes, solids with conventional and CAD software.	L3 & L6
3	Visualize the actual objects and convert them in to readable drawings with conventional and CAD software.	L6
4	Create new designs/engineering models with conventional and CAD software.	L6

CO-PO & PSO Course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Drawing, P. S. Gill, S.K. Kataria & Sons.	2012
2	Engineering Drawing, D.A. Jolhe, Tata McGraw Hill	2010
3	Engineering Graphics with SOLIDWORKS, David C. Plan chard, SDC Publications	2020

Course Name	:	Introduction to Mechatronics
Course Code	:	ES 2304
Credits	:	04
L T P	:	3-0-2
Course Objectives:		
The objective of the course content is to:		
<ol style="list-style-type: none"> 1. Impart knowledge and information about mechatronics system. 2. Understand the concepts of signal conditioning and data acquisition for intelligent systems. 3. Develop the basics for mechatronic product design 		

Total No. of Lectures-42

Introduction to Mechatronics : Introduction, Elements of Mechatronics system, Classification of Mechatronics system, Mechatronic system intelligence, Components involved in intelligent system design and development, measurements and control system as a part of mechatronics system, Application of Mechatronic systems(6)

Sensors and transducers : Introduction, Performance characteristics of transducers, Transducer for displacement (Potentiometer, strain-gauge, Optical encoder, LVDT, Hall effect sensor); velocity (Tachogenerator), force (load cell), pressure (Piezoelectric sensors, Tactile sensor), liquid level (Floats, Differential pressure), Temperature (Bimetallic strips, RTDs, Thermistors, Thermocouples) and light sensor (Photovoltaic- transducer, LDR, Photodiode, Photo Transistor). (8)

Signal conditioning: Operational amplifier (Inverting, Non-inverting, Summing, Integrating, Differential amplifiers, comparator), protection, filtering, digital signals (R-2R ladder DAC and Successive Approximation ADC), Concepts of multiplexers(7)

Controllers: Basics of number system, binary, octal and hexadecimal systems with their conversion from one system to other. Boolean algebra, logic gates, ICs, flip-flops & counters. Microprocessor, Microcontroller, PLC & their Architectures, Working Principle, Software Programs (Assembly/High Level), Interfacing Aspects (7)

Actuators and mechanisms:

Pneumatic and hydraulic actuation systems: Directional control valves, Pressure control valves, cylinders
Mechanical actuation systems: Kinematic chain, cam, gear, clutches, ratchet and pawl, belt and chain drive, bearings

Electrical actuation systems: Relays, Solid-state Switches (Diode, Thyristor, Triac, BJT, FET), DC and AC motors, brushless dc motor, stepper motors, servomotors (8)

Robotics: Types of motions, Function, Governing Laws, Classification, Features and Components of Robots, System Automation(6)

Topics to be thought through Flipped Learning (NPTEL MOOCs) -

<https://nptel.ac.in/courses/112107298>

Mechanical actuation systems: Kinematic chain, cam, gear, ratchet and pawl, belt and chain drive, bearings (Unit 3 Lecture 11)

Pneumatic and hydraulic actuation systems: Directional control valves, Pressure control valves, cylinders (Unit 3 Lecture 12)

Basics of number, binary, octal and hexadecimal systems with their conversion from one system to other. Boolean algebra, logic gates, ICs, flip-flops. (Unit 5 Lecture 21 & 22)

PLC Controller (Unit 7 Lecture 33)

LIST OF EXPERIMENTS		
1	Experiment on Sensors & Transducers	Number of Turns
(i)	To study the characteristics of LVDT using linear displacement trainer kit & compare with ideal characteristics.	01
(ii)	To measure the strain of the metal strip using strain gauge trainer kit & compare with ideal characteristics.	01
(iii)	To measure the angular displacement of resistive & capacitive transducer using angular displacement trainer kit & compare with ideal characteristics.	01
(iv)	To obtain the characteristics of RTD, thermistor, thermocouple with hot and cold junction thermal trainer kit & compare with ideal characteristics.	01
2.	Experiments on Signal Conditioning.	
(a)	Experiments on Analog Devices	
(i)	PN Junction Diode	01
(ii)	Zener Diode	01
(iii)	Half wave rectifier	01
(iv)	Full wave rectifier	01
(b)	Experiments on Digital devices	
(i)	Logic Gates (AND, OR, NAND, NOR etc)	01
(ii)	Flip Flop - RS Flip Flop, JK Flip Flop, T Flip Flop and D Flip Flop.	01
3	Experiments on Controller	
(i)	To perform the basic sequence programming using PLC.	01
4.	Experiments on Actuators	
(i)	To perform AND and OR logic using pneumatic actuators.	01
5.	Project using Arduino	
(i)	To build a line follower robot using Arduino.	02

Course Outcomes:

By the end of this course, the student will be able:

CO1: To understand the basic concepts, applications and components of mechatronic system.

CO2: To analyze sensing, signal conditioning and data acquisition circuits.

CO3: To design product and systems theoretically as well as practically with Intelligence.

CO4: To apply the knowledge of mechatronic system for industrial applications.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechatronics by W Bolton , 6 th edition, Pearson Education	2019
2	Mechatronics by Tilak Thakur 1 st edition, Oxford University Press	2016
3	Mechatronics by Dan Neculescu, Pearson Education	2001
4	Mechatronics by H M T Limited,TMH	2017
5	Mechatronics Principles, Concepts & Applications by Nitaigour P Mahalik, TMH	2017

Course Name	Introduction To Electronics & Electrical Engineering
Course Code	ES 2305
Credits	4
L T P	3-0-2

Course Objectives:

To introduce to the students, the fundamental concepts of electronic devices, circuits and electrical systems for engineering applications.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	Semiconductor Devices and applications: Introduction to different semiconductor materials, familiarization with active and passive components, operation of p-n junction diode, applications of diodes, introduction to BJT and MOSFET, transistor as an amplifier, transistor as a switch, functional operation of OpAmp, concept of Oscillators, filters and their types	10
2	Digital Electronics: Number system, Binary arithmetic, Binary codes, introduction to logic gates, combinational circuits: adder, subtractor, multiplexer, demultiplexer, sequential circuit: flipflops.	9
3	Communication Systems: Basics of signals and systems, time and frequency domain analysis, various frequency bands used for communication, block diagram of Analog and Digital communication, need of modulation, Introduction to wired and wireless communication.	10
4	Fundamentals of Electrical Engineering: Introduction to circuit laws, amplitude, phase, phase difference, RMS value and average value of an AC signal, introduction and types of motors, Transformer: construction, working principle and applications	7
5	Microprocessor and Microcontroller: Introduction to microprocessor and microcontroller, architecture of 8086, functional diagram, register organization, memory segmentation	6

List of Experiments

S. No.	Name of the experiment	No. of turns
1	To familiarise with basic electronic components, oscilloscopes, power supply, multimeter etc.	2
2	To simulate and analyse the IV characteristics of PN junction diode	1
3	To simulate and analyse the functionality of opamp	2
4	To simulate and verify the truth tables of various logic gates	1
5	To simulate and analyse various combinational circuits	2
6	To simulate and verify the truth tables of various flip-flops	2
7	To familiarise with microprocessor and microcontroller kits	2
8	Write a MATLAB program for the generation of standard signals	1
9	To implement amplitude modulation and demodulation by using MATLAB	1

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

1	Express the understanding of semiconductor devices (p-n Diode, BJT, MOSFET etc), and their applications.
2	Demonstrate the functional operation of various analog and digital electronic circuits.
3	Solve basic electronic circuits using circuit laws.
4	Describe various signals, systems and fundamentals of communication systems.

5	Describe the basic principle and working of fundamental electrical systems, ac dc motors and transformer etc.
6	Explain the fundamentals of microprocessors and microcontrollers.

Suggested Books:

S. No.	Name of Book/ Authors/ Publishers	Year of Publication/ Reprint
1	Electronics Devices & Circuit Theory, RL Boylestead & L Nashelsky (PHI)	2009
2	Circuits and Networks: Analysis and Synthesis, Sudhakar and Shyam Mohan, TMH	2009
3	Electronic Communication Systems by G. Kennedy, Mc Graw Hill, 4 th Edition	2008
4	Digital Principles and Applications, 7 th Edition, A. Malvino and D. Leach	2011
5	Alexander, Charles K., and Sadiku, Matthew N. O., Fundamentals of Electric Circuits, 5 th Ed, McGraw Hill	2013
6	A course in Electrical and Electronic Measurements and Instrumentation, A K. Sawhney, 18 th Edition, Dhanpat Rai & Sons	2001
7	Microprocessors and Microcontrollers Architecture, Programming and Interfacing Using 8085, 8086 and 8051, Soumitra Mandal, Tata McGraw-Hill	2017

Course Name	:	Introduction to Product Design
Course Code	:	ES -2307
Credits	:	2
LTP	:	0-0-4

Course Objectives:

To demonstrate the concepts Product Design and Development skills through: Additive Manufacturing, Reverse Engineering, CNC machining, Laser engraving and Robotic

Course Outcomes:

1	Apply the fundamental concepts and principles of reverse engineering in product design and development.
2	Understand the process and applications of Additive Manufacturing for Product development
3	Understand the concepts and applications of CNC machines & Robot and its interface.

Practical's

Total: 56 hours

Sr. No.	Name	No of turns
1	Prepare a CAD model of given Product using NX Software	4X2
2	Reverse Engineering (3D Scanning, Repair and measurement) of given product for development of CAD model	4X2
3	Converting CT/MRI scan data using MIMICS Software to Develop the CAD model	4X1
4	Tessellation of various CAD models into STL file and Simulation of process parameters using software and its validation	4X1
5	Fabrication of CAD model using polymers based 3D Printer for Product development	4X1
6	To study various CNC machine codes and addresses and write a programme for a given profile	4X1
7	To execute the part program on CNC trainer kit followed by product fabrication on CNC machine tool	4X1
8	Demonstrate the various components of industrial robots and programming the Robot for pick and place application	4X1
9	To design a circuit using the PLC concept for automated devices	4X1
10	To sketching given design using CorelDRAW and fabricate the product using Laser engraving	4X1
11	To measure the surface integrity of given Product using advance measurement techniques	4X2

Course Name	:	Introduction to Environmental Sciences
Course Code	:	GS 2301 (Common to all branches)
Credits	:	1
L T P	:	1 0 0

Course Objectives:

This course aims to (i) acquaint the students with the basics of Environmental Science (ii) make them aware of the importance of Environmental Science

Total No. of Lectures – 14

Lecture-wise breakup		No. of Lectures
Unit 1	Multi-disciplinary Nature of Environmental Studies; Environmental Problems and their Causes, Concept of Sustainability; Sustainable Development, Sustainable Development Goals (SDG).	2
Unit 2	Types of Ecosystems - System Dynamics - Understanding Ecosystems, Ecosystem Degradation, Ecosystem Delivery, Habitat Classification.	2
Unit 3	Natural Resources and Associated Problems, Non Renewable Resources, Renewable Resources, Resource Utilization.	2
Unit 4	Energy and Environment – Fossil Fuel, Geothermal, Tidal, Nuclear, Solar, Wind, Hydropower and Biomass.	2
Unit 5	Environmental Pollution – Air Pollution, Water Pollution, Soil Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Nuclear Hazards ; Global Environmental Issues ; Solutions to Pollution Problems.	2
Unit 6	Cleaner Production and Life Cycle Analysis - LCA Methodology, Steps and Tools; EIA and Environment Audit.	2
Unit 7	Environment, Development and Society- Emerging Technologies for Sustainable Development and Environmental Management; Policies and Practices, Legislation; Disaster Management.	2

Course Outcomes (COs):

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

1	Relate the importance of environmental science for sustainable development of society.
2	Apply the principles of environmental science and the concept of sustainable development in real life engineering problems.

Test Books		Year of Publication/ Reprint
S.No.	Name of Book	
1	“Environmental Science”, Miller G.T. and Spool, Ceonage Learning Publications.	2021
2	“Environmental Studies”, Banny Joseph, Tata Mcgraw Hill Publication.	2021
3	“Text book of Environmental Studies for U.G. Courses”, Erach Bharucna , University Press.	2021
4	“Environmental Studies – from criteria to cure”, R. Raogopalan, Oxford Univ. Press.	2022
5	“Principles of Environmental Science – Inquiry and applications”, Mary Ann Cunningham, William P. Cunningham, TMH Edition.	2020

Course Name	Universal Human Values
Couse Code	GS2302
Credits	1
L T P	1-0-0

Objectives:
<p>The course has the following objectives-</p> <p>CO1-To equip students with foundation in ethical decision-making, teamwork, and social responsibility.</p> <p>CO2-To emphasize the integration of technical skills with ethical principles to prepare students for responsible and ethical professional practices.</p> <p>CO3-To shape students into well-rounded individuals with strong ethical foundation that guides their actions, decision and interactions with world around them.</p>

Total Number of Lectures: 14

Lecture wise Breakup	Number of Lectures
<p>Course Introduction: Need, Basic Guidelines, Content & Process for Value Education</p> <p>Understanding ethics, morals, and values Ethical theories and their application in engineering and technology</p>	2
<p>Ethical Decision-Making</p> <p>Steps in ethical decision-making Identifying and analysing ethical dilemmas in real-world scenarios</p>	3
<p>Teamwork and Collaboration</p> <p>Characteristics of effective teams Conflict resolution and managing differences Collaboration tools and techniques for virtual teams</p>	3
<p>Social Responsibility and Sustainability</p> <p>Role of engineers in promoting social good Environmental ethics and sustainable development Corporate social responsibility and ethical considerations in technology choices</p>	3
<p>Ethical analysis of Technological Innovations</p> <p>Engineering Ethics Balancing short-term gains with long-term consequences</p>	3

Course Outcomes:
<p>Some of the key outcomes that students can expect after completing this course:</p> <p>CO1-Increased awareness of ethical issues in both personal and professional contexts.</p> <p>CO2-Encourages critical thinking skills, allowing students to analyse complex situations from multiple angles and evaluate the ethical implications of different actions.</p> <p>CO3-Promotes an understanding of diverse cultures, beliefs, and backgrounds, fostering an inclusive mindset.</p> <p>CO4-Engage in self-reflection and introspection, leading to personal growth and a better understanding of their own values, strengths, and areas for improvement.</p>

Suggested Books:		
<i>S.No.</i>	<i>Name of Book/ Authors/ Publisher</i>	<i>Year of Publication/ Reprint</i>
1	"Engineering Ethics" (Includes Human Values), Govindarajan M, Pearson Education Inc.	2017
2	"Professional Ethics and Human Values", Govindarajan M, Learning India Private Limited.	2020
3	"Professional Ethics and Human Values (JNTU-Kakinada)", B Raghavan, McGraw Hill.	2021
4	"The Moral Status of Technical Artefacts (Philosophy of Engineering and Technology)", Peter Kroes and Peter-Paul Verbeek	2020
5	"Ethics and Professionalism in Engineering (Broadview Guides to Business and Professional Ethics)" by Richard H McCuen and Kristin L Gilroy., Pubs: W.W. Norton & Company.	2020
6	"Engineering Ethics: Challenges and Opportunities" by W Richard Bowen, Cengage Learning	2019

Additional Reading-

<i>S.No.</i>	<i>Name of Book/ Authors/ Publisher</i>	<i>Year of Publication/ Reprint</i>
1	A Casebook in Interprofessional Ethics: A Succinct Introduction to Ethics for the Health Professions (SpringerBriefs in Ethics)", Jeffrey P Spike and Rebecca Lunstroth,2 Pearson Education Inc	2020
2	"Fundamentals of Ethics for Scientists and Engineers", Edmund G Seebauer and Robert L Barry,2020, Pearson Education Inc.	2020

SYLLABUS

Course Name	:	Communication Skills
Course Code	:	HS2351
Credits	:	3
L T P	:	2-0-2

Course Objectives
<p>The objective of the course content is:</p> <p>CO1: To explain different aspects of communication process and enable the students to develop a strong theoretical base to handle various real-life communication tasks.</p> <p>CO2: To provide opportunities to the students to acquire and practice their LSRW skills in English for effective communication in professional life.</p> <p>CO3: To enable the students to articulate their ideas and perspectives using appropriate communication strategies and tools.</p> <p>CO4: To develop critical thinking and creative writing skills among the students and equip them with necessary analytical tools to achieve success in personal and professional domains.</p>

Total No. of Lectures – 28

Lecture-wise Breakup		No. of Lectures
1	<p>Introduction to Communication</p> <p>Concept, Process, Modes – verbal (oral and written) and non-verbal (kinesics, proxemics, chronemics), Types (formal, semi-formal, and informal), Channels (downward, upward, horizontal, diagonal), and Levels (extrapersonal, interpersonal, intrapersonal, organizational, and mass) of Communication, Barriers to Effective Communication with Solutions, Significance and Tools of Effective Communication.</p>	(4)
2	<p>Developing Effective Listening and Speaking Skills</p> <p>Hearing versus Listening, Listening Process (hearing, understanding, remembering, evaluating and responding), Note-taking, Barriers to Listening, and Strategies for Effective Listening.</p> <p>Tools and Techniques (linguistic and paralinguistic) of Effective Speaking at Various Levels (interpersonal, group, organization and society), Art of Conversation, Dialogue, Discussion, Public Speaking, Presentation, Negotiation, and Persuasion.</p>	(7)
3	<p>Developing Reading and Technical Writing Skills</p> <p>Concept, Strategies and Techniques (skimming, scanning, inferring, close reading) for Effective Reading and Comprehension, Understanding and Summarizing the Gist.</p> <p>Tips for Effective Technical Writing, Formal Letter Writing, Notice, E-mail Writing, Precis Writing, Statement of Purpose, and IMRD-Based Report.</p>	(8)

4	Critical and Creative Thinking Skills Descriptive, Referential, Inferential, Discursive, Analytical, Evaluative, Creative and Lateral Using Texts and Various Media Forms like Books, Newspaper Articles, Films, and Social Visuals.	(4)
5	Job Preparation Sensitization to Building Portfolio, Job/Cover Letter and Resume, Interview Skills	(3)
6	Digital Media for Effective Communication Introduction, Current Trends in e-learning, Online Meetings, Digital Media Tools and Apps for Enhancing Communication Skills	(2)

Total No. of Practical Sessions: 14

Practical Session Wise Breakup		No. of Practical Sessions
1	Organizational Communication Verbal, Vocal and Non-Verbal Communication in Practice, Greetings and Self-Introduction, Speech, and JAM.	(2)
2	Speaking Techniques at Different Forums Group Discussion, Role-play, Making and Presenting Power Point Presentations.	(3)
3	Practice on Reading and Technical Writing Reading Comprehension, Formal Letter Writing, Précis Writing, Notice, Email Writing, Report Writing, and Statement of Purpose	(3)
4	Applying Critical Thinking Skills Book Review, Film Review, Social Visuals -Interpretation and Critical Analysis.	(3)
5	Towards Job Preparation Sensitization to Building Portfolio, Job/Cover Letter, Resume, Interview	(2)
6	Use of Digital Media for Effective Communication Training the students to use digital tools	(1)

OBJECTIVES OF THE COURSE

The objective of the course content is:

CO1: To explain different aspects of communication process and enable the students to develop a strong theoretical base to handle various real-life communication tasks.

CO2: To provide opportunities to the students to acquire and practice their LSRW skills in English for effective communication in professional life.

CO3: To enable the students to articulate their ideas and perspectives using appropriate communication strategies and tools.

CO4: To develop critical thinking and creative writing skills among the students and equip them with necessary analytical tools to achieve success in personal and professional domains.

OUTCOMES OF THE COURSE

By the end of this course, the students will be able to:

1. Understand the basic concepts of effective communication and learn the importance of communication skills for professional purposes.
2. Apply the four skills of language effectively by using latest learning strategies and digital tools to create and produce original pieces of technical writing and speech.
3. Analyse and evaluate critically what they listen, read and write to respond appropriately in different contexts of their personal and professional life.

Course Name	:	CALCULUS
Course Code	:	MA2301
Credits	:	4
L T P	:	3-0-2
Total No. of Lectures	:	42

Course Objectives:

At the end of the semester, the students should be able to

1	Understand the behavior of infinite series and their use.
2	Learn the concepts related to differential calculus of functions of several variables and their applications.
3	Learn the concept and methods of evaluating multiple integrals and their applications to various problems.

	Lecture wise breakup	No. of Lectures
1	INFINITE SERIES Limits of sequences of numbers, Theorems of calculating limits of sequences, Infinite series and convergence, alternating series, power series and convergence. Taylor's and Maclaurin's Series. (Scope as in Chapter 8, Sections 8.1 – 8.9 of Text Book 1).	12
2	DIFFERENTIAL CALCULUS Functions of several variables, Limits and continuity, Partial Derivatives, Euler's Theorem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula. (Scope as in Chapter 12, Sections 12.1 – 12.6, 12.8 – 12.10 of Text Book 1).	14
3	INTEGRAL CALCULUS Parametrization of plane curves, Polar coordinates, Graphing in Polar coordinates, Cylinders and Quadric surfaces, Double integrals in Rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical Coordinates, Substitutions in Multiple integrals. Applications to practical problems. (Scope as in Chapter 9, Sections 9.4, 9.6 and 9.7 ,Chapter10, Sections10.6 and 10.7 and Chapter 13, Sections 13.1, 13.3, 13.4,13.6 and 13.7 of Text Book 1).	16

Course Outcomes:

At the end of the semester, the students are able to

1	Test the behavior of infinite series.
2	Apply the concepts of differential calculus of functions of several variables.
3	Evaluate multiple integrals and apply them to practical problems.

Text Books:

1	Calculus and Analytic Geometry, Thomas and Finney, 9 th edition, Pearson Education Asia.	2006
---	---	------

Reference Books:

1	Advanced Engineering Mathematics, Wylie and Barrett, 6 th edition, Mc Graw Hill.	2003
---	---	------

Practical / Lab work to be performed using Mathematica/ Matlab

1. Study the convergence of sequences through plotting.
2. Analyze the convergence of infinite series by plotting their sequences of partial sums.
3. Study the convergence of infinite series using Cauchy's root test and Ratio test
4. Taylor and Maclaurin series of trigonometric, logarithmic, hyperbolic functions.
5. Plotting 2D curves in rectangular and polar coordinates.
6. Plotting 3D surfaces.
7. Find critical points and identify local maxima, local minima or saddle points
8. Draw the surfaces and analyze the existence of limits as they approach the specified points.
9. Check the continuity of functions
10. Draw the surfaces and find level curves at the given heights

Course Name	:	LINEAR ALGEBRA, DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS
Course Code	:	MA2302
Credits	:	4
L T P	:	3-0-2
Total No. of Lectures	:	42

Course Objectives:

At the end of the semester, the students should be able to

1	Learn the various concepts associated with real vector spaces and theory of matrices
2	Learn the methods to solve ordinary differential equations of various types.
3	Learn the various concepts of vector calculus and their applications to problems.

	Lecture wise breakup	No. of Lectures
1	ALGEBRA Vector spaces over reals, Linear dependence, Basis, Dimension, Co-ordinates with respect to a basis, Change of basis, Subspace, Linear transformation $R^n \rightarrow R^m$, Range space and Rank, Null space and Nullity, Rank and Nullity relation, Matrix representation of a linear transformation, Similar matrices, Invertible linear transformation, Eigenvalues and eigenvectors, Cayley Hamilton theorem, Diagonalization of a matrix.	16
2	ORDINARY DIFFERENTIAL EQUATIONS First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian.	12
3	VECTOR CALCULUS Gradient, Divergence and Curl – their physical interpretation, Line, Surface and Volume integrals, Green's theorem in the plane, Stoke's theorem, Divergence theorem, Applications to Science and Engineering.	14

Course Outcomes:

At the end of the semester, the students are able to

1	Solve the various problems related to real vector spaces and theory of matrices
2	Solve ordinary differential equations of various types
3	Apply various concepts of vector calculus to problems.

Text Books:

1	Introductory Linear Algebra with Applications, Kolman, B. and Hill, D.R., 7 th edition, Pearson Education	2001
2	Advanced Engineering Mathematics, Kreyszig, 8 th edition, John Wiley and Sons.	2005

Reference Books:

1	Differential Equations, S. L. Ross, John Wiley and Sons, India	2004
2	Advanced Engineering Mathematics, Wylie and Barrett, 6 th edition, Mc Graw Hill.	2003
3	Differential Equations, Frank Ayers, SI edition, Mc Graw Hill.	1972

Practical / Lab work to be performed using Mathematica/ Matlab

1. Perform basic Matrix operations.
2. Find rank, eigenvalues and eigenspace of matrices.
3. Check diagonalizability of matrices.
4. Solve ordinary differential equation.
5. Plotting of second order solution family of differential equation.
6. Plotting of third order solution family of differential equation.
7. Plotting of vector fields.
8. Find Gradient, Divergence and Curl.
9. Computation of line integrals and surface integrals.
10. Verify Green's theorem in the plane, Stoke's theorem, Divergence theorem.

Course Name	:	Electromagnetic Theory and Quantum Physics
Course Code	:	PY2301
Credits	:	4
L T P	:	3 0 2

Course Objectives:

1. To familiarize the students with the concepts of electrostatics and boundary value problems.
2. To make the students able to understand the magnetostatics and their boundary value problems.
3. To make the students able to understand and apply the concepts of electromagnetic wave propagation.
4. To familiarize the students with the concepts and principles of Quantum Mechanics.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	VECTORS, FIELDS AND ELECTROSTATICS: Cartesian coordinate System, Cylindrical and Spherical coordinate Systems, Gradient, Divergence of a Vector and Divergence Theorem, Curl of a vector and Stoke's theorem, Gauss's law & its applications, Maxwell's 1st eqn. (Electrostatics), Electric Energy and potential, Potential gradient, the dipole fields, Energy density in an electrostatic field. Current and current density, Continuity of current, Metallic conductors, Dielectric materials, Electrostatic boundary-value problems, Introduction to Laplace's and Poisson's equations.	12
2	MAGNETOSTATICS: Biot-Savart's law, Ampere's circuital law, Magnetic flux and magnetic flux density, Scalar and vector magnetic potentials. Magnetic dipole, Force due to Magnetic field on a differential current element, force between two differential current elements, Force and torque on a closed circuit, magnetic materials, Magnetic boundary conditions, Inductors and inductances.	10
3	MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVE PROPAGATION: Faraday's law, Displacement current, Maxwell's equations in point form, Maxwell's equations in integral form, EM waves in general, EM wave propagation in Lossy Dielectrics, Wave propagation in lossless dielectrics, Plane waves in free space, Plane waves in Good conductors, Power & Poynting Vector, Reflection of a plane wave at normal incidence.	10
4	QUANTUM PHYSICS: Need of Quantum theory, Photoelectric effect, The Compton effect; matter waves, group and phase velocities; Uncertainty principle and its application; time independent and time dependent Schrödinger wave equation; Eigen values and Eigen functions, Born's interpretation and normalization of wave function, applications of Schrödinger wave equation for particle in one dimensional infinite potential well. Introduction to nanoscience, Quantum materials, and Superconductivity.	10

List of Experiments:		Number of Turns
1	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO ₃ .	1
2	To determine coercivity of magnetic material using hysteresis loop tracer.	1
3	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
4	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
5	To design a method to draw equipotential lines with various geometries of electrodes kept at different potentials.	1
6	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1
7	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1

8	To plot I-V Characteristics of Solar cell.	1
---	--	---

Course Outcomes: By the end of the course

1	Students will be equipped with the tools of electromagnetic theory.
2	Students will be able to solve numerical problems based on electrostatics, magnetostatics, electromagnetic wave propagation.
3	Students will be able to understand and apply the basic concepts of Quantum Mechanics.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Electromagnetics, William H Hyat, Jr., and John A. Buck, Tata McGraw Hill	2013 / 5 th edition
2	Elements of Engineering Electromagnetics, Matthew N.O. Sadiku, Oxford University Press	2012 / 4 th edition
3	Concepts of Modern Physics, Arthur Beiser, McGraw Hill Education (India) Pvt. Ltd., New Delhi.	2013
4	Modern Physics, J. Bernstein, P.M. Fishbane and S.G. Gasiorowicz, Pearson, Education India Pvt. Ltd., New Delhi	2009

Course Name	:	Mechanics and Optics
Course Code	:	PY2302
Credits	:	4
L T P	:	3-0-2

Course Objectives:

1. To inculcate the application of Mechanics concepts in engineering
2. To familiarize students with Statics, Kinematics, and Kinetics of rigid body.
3. To familiarize the students with Ultrasonics and their applications.
4. To familiarize students the basic concepts of LASER and Nanotechnology for possible industrial applications.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	STATICS AND DYNAMICS: Analysis of system of forces, Equation of equilibrium in space and its applications, Center of gravity, Centroid, mass, area and Polar moment of inertia of simple and compound bodies. Kinematics of a Particle: Introduction, Motion of a projectile, Kinetics of a particle: Force and acceleration, Work and energy, Impulse and momentum.	10
2	PLANAR KINEMATICS AND KINETICS OF A RIGID BODY: Rigid-body motion, Translation, Rotation about a fixed axis, Absolute general Plane Motion analysis. Relative-Motion Analysis: Velocity, Instantaneous center of zero velocity, Acceleration. Moment of Inertia, Planar Kinetic equations of motion, Equations of motion: Translation, Rotation about a fixed axis and General Plane motion, Kinetic Energy, Work of a Force, Work of a Couple, Principle of Work and Energy, Conservation of Energy, Linear and Angular Momentum, Principle of Impulse and Momentum, Conservation of Momentum, Eccentric Impact.	12
3	LASERS, OPTICAL FIBRES AND ULTRASONICS: Basics of Interference, Diffraction and Polarization, Michelson–Morley Interferometer, Raman effect, Laser and its characteristics, He-Ne laser, Ruby laser, Semiconductor lasers, Ultra-fast lasers, Applications of Lasers, Optical fibres; Numerical aperture, Classification of optical fibres, fibre Losses, fibre manufacturing, Applications of optical fibres. Production of ultrasonics, detection and uses of ultrasonics, reverberation.	12
4	NANOTECHNOLOGY: Introduction, Length Scale, Size Dependence, Synthesis of Nanoparticles: Mechanical Method, Sol-gel Technique, Physical Vapour Deposition, Chemical Vapour Deposition, Overview of Carbon-based nanostructures, X-ray Diffraction for nano-materials analysis, Applications of Nanotechnology, Introduction to Quantum Materials and Superconductors.	8

List of Experiments		No.of Turns
1.	Familiarization of students with basic instruments Vernier Calipers, Screw Gauge and Spectrometer.	1
2.	(i) To determine the wavelength of He-Ne laser using transmission grating. (ii) To determine the slit width using the diffraction pattern.	1
3.	To find the specific rotation of sugar solution using a Bi-quartz Polarimeter.	
4.	To determine the acceleration of gravity using Kater's pendulum	1
5.	To determine the Moment of Inertia of a Flywheel.	1
6.	To determine the range of the projectile as a function of angle of inclination and initial velocity.	1
7.	To determine the velocity of ultrasonic waves in a given liquid.	1
8.	To measure the centripetal force, F_c , and compare to $F_c = mv^2/r = m\omega^2r$.	1

Course Outcomes:	
1	Students will be able to understand and implement the concepts of Mechanics, types of motions and characteristics of rigid body.
2	Students will learn about lasers and fibre optics which have important applications for societal needs.
3	Students are expected to develop capability to tackle problems in general and in the various areas covered in the course.

Suggested Books:	
Sr. No.	Name of Book/ Authors/ Publisher/Edition
1	Statics, R.C. Hibbeler, Pearson (11th Edition).
	Dynamics, R.C. Hibbeler, Pearson (11th Edition).
2	Dynamics, F.P. Beer et al., McGraw Hill (8th Edition).
3	Dynamics, Merriam and Kraige, Wiley and Sons (5th Edition).
4	Engineering Mechanics, G. Ramamurthy, R. S. Walia and Rajesh Kumar, I K International (3rd Edition).
5	Optics, Ajoy Ghatak, McGraw-Hill (3rd Edition).
6	Physics for Engineers, N.K. Verma, Prentice Hall India (3rd Edition).
7	Engineering Physics, Satya Prakash, Pragati Prakashan (9th Edition)

Course Name	:	CONDENSED MATTER PHYSICS
Course Code	:	PY2303
Credits	:	4
L T P	:	3 - 2/2

Total No. of Lectures – 42

Course Objectives:	
1.	To familiarize the students with basic concepts of the condensed phase of matter especially solids.
2.	To make the students able to understand the crystal structure, lattice vibrations, electronic properties, dielectric and the magnetic properties etc. in relation to engineering applications.
3.	To make the students able to understand the basics concepts of semiconductors, superconductivity, and their applications in various fields.
4.	To familiarize students the basic concepts of LASER and Nanotechnology for possible industrial applications.

Lecture wise breakup	No. of Lectures
-----------------------------	------------------------

1	Crystal structure and Band Theory of Solids: -Space lattices crystal structures (cubic and hexagonal cells), close packed morphology (Hexagonal and cubic close packing), single and polycrystalline structures, crystal Structure analysis, X-ray diffraction and Bragg's law, Classical and Quantum Theory of free electrons, Fermi-Dirac Distribution Function, Density of States, Motion of electrons in magnetic field (Hall effect), Energy bands in solids. Introduction of Phonons, Vibrations of one dimensional monoatomic and diatomic lattices, Momentum of Phonons. Electron in a Periodic Potential (Qualitative idea of Kronig Penney Model), Energy versus wave vector,	(14)
2	Dielectric and Magnetic Materials: Fundamental of dielectrics, active and passive dielectrics, various polarization mechanisms, Frequency and temperature dependence on polarization of dielectrics, Internal field, Dielectric Loss Tangent, Dielectric Breakdown. Review of basic formulas, magnetic susceptibility, classification of materials, anti-ferromagnetism and ferrimagnetism, ferromagnetism in metals, ferromagnetic domains, hysteresis, antiferromagnetism.	(7)
3	Semiconductors and Superconductivity: Introduction, Pure or Intrinsic Semiconductors, impurity or Extrinsic semiconductors, Drift velocity, mobility and Conductivity of Intrinsic Semiconductors, carrier concentration and Fermi level for Intrinsic and Extrinsic Semiconductors, Applications: P-N Junction diode, Zener diode and Tunnel diode. Introduction to superconductivity, Mechanism of superconductivity, Meissner Effect, Effect of current and magnetic field, Type I and Type II superconductors, Thermal properties, Isotope effect, London Equations, Qualitative idea of BCS theory, Applications of superconductivity.	(14)
4	Nanotechnology: Introduction, Length Scale, Size Dependence, Synthesis of Nanoparticles: Mechanical Method, Sol-gel Technique, Physical Vapour Deposition, Chemical Vapour Deposition, Overview of Carbon-based nanostructures, X-ray Diffraction for nano-materials analysis, Applications of Nanotechnology, Introduction to Quantum Materials.	(7)

S.No	List of Experiments	No. of
-------------	----------------------------	---------------

		turns
1.	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO ₃ .	1
2.	To determine coercivity of magnetic material using hysteresis loop tracer.	1
3.	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
4.	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
5.	To design a method to draw equipotential lines with various geometries of electrodes kept at different potentials.	1
6.	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1
7.	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1

Course Outcomes: By the end of the course	
1	Students will be able to understand the physics behind structural properties of the solids.
2	Students will be aware of latest developments in certain areas of condensed matter physics, which have important applications for societal needs.
3	Students are expected to develop capability to tackle problems in general and in various areas covered in the course.

Suggested Books:	
Sr. No	Name of Book/ Authors/ Publisher
1.	Introduction to Solid State Physics, Charles Kittel, Wiley India Pvt. Ltd., New Delhi (8 th Edition)
2.	Solid State Physics, S.O. Pillai, New Age International, Pvt. Ltd., New Delhi (5 th Edition)
3.	Solid State Physics, M. A. Wahab, Narosa Publishing House, Pvt. Ltd. New Delhi (3 rd Edition).
4.	Solid State Physics R.K. Puri, V.K.Babbar, S. Chand & Company, Pvt. Ltd. New Delhi (3 rd Edition).

Departmental Core Courses

Course Name	:	ELEMENTS OF MANUFACTURING PROCESSES
Course Code	:	MEN3001
Credits	:	4
L T P	:	3-0-2

Sr.No.	Course Objectives:
1.	To familiarize the students with the basic tools and equipment's used in manufacturing shops.
2.	To familiarize with basic manufacturing processes, techniques, use of machine tool etc.
3.	To introduce the practical knowledge on different aspects of manufacturing processes.
4.	To familiarize with the production of basic raw materials like casting, powder metallurgy, and secondary processes like forming, joining, and assembly.

No. of Lectures – 42		
Lecture wise breakup		No. of Lectures
1.	INTRODUCTION: Introduction to Manufacturing, Classification, Concept of product design and development, Manufacturing activities inside and outside the factory, Inventory, storing of materials and shop floor control, Industrial safety, Materials in manufacturing, Conventional, Lean, Green, Sustainable and Smart Manufacturing, Computer integrated manufacturing.	6
2.	CASTING: Definition and significance, Raw materials for casting, Patterns, Mould, Core and core making; Cupola, Induction and Resistance heating furnaces, Open hearth and Pit furnace; Sand casting, Mechanics of solidifications, Chvorinov's rule and Caine's principle, Centre line resistance factor, Adams and Taylor method; Design of gating system, runner and riser, Calculation of Reynold number and types of flow, Aspiration effect; Pouring time calculation, Degassing, Fettling, Casting defects: Causes and their remedial actions; Centrifugal casting and estimation of mould rotational speed, carbon dioxide, plaster mould casting, shell moulding, precision casting, investment casting, die casting, Continuous casting; Inspection, testing, defects and salvaging techniques of defects.	7
3.	METAL FORMING: Definition, Classification, Hot and Cold working processes; Bulk deformation processes: Rolling, Thread rolling, Piercing, Mechanics of seam less tube manufacturing, Spinning, Extrusion, Estimation of extrusion pressure and force; Wire, tube, cup and deep drawing; Forging, bending, shearing, coining, embossing, punching, blanking, fullering, edging, trimming; Open and closed die forging, and estimation of compressive force; Hydroforming, electrohydraulic, electromagnetic and Stretch forming; Rotary swaging, ring rolling, gear rolling, planetary and tandem rolling, Erichsen cupping, spline shaft rolling, transverse rolling dies and hybrid forming; Forming defects: causes and remedial actions.	8
4.	WELDING: Definition, classification, mechanics of homogeneous, heterogeneous and autogeneous welding, weldability. <i>Arc welding:</i> physics of arc welding, types, CAW, SMAW, FCAW, GMAW, IGAW, GTAW, TIGW, MIG, submerged and plasma arc welding; Atomic hydrogen, electro slag, electron beam, laser beam and stud welding; <i>Electrodes:</i> Types, classification and codification, selection procedure and applications; Resistance welding: Principle, types, Spot-welding and spot welding machine, Projection, Seam, Butt, Percussion welding; Solid state welding: Cold, diffusion, ultrasonic, explosive, FSW, HPW, Flow welding, forge and friction welding; <i>Thermochemical welding:</i> Principle, types, applications; Thermit welding; <i>Gas welding:</i> Types, Physics of oxy-acetylene gas welding, different zone and temperature of oxy-acetylene flames, and applications. <i>Oxy-flame cutting:</i> Principle, types, application; <i>Brazing and soldering:</i> Principle, types, materials, application in macro and micro domain, Fabrication of PC integrated circuit board; Welding defects: Causes and remedial actions.	9

5.	POWDER METALLURGY: Powder metallurgy: principle, advantages and limitations, Methods of producing powders, Flow process and operations involved in making metal powder parts, Powder blending, compaction and sintering, Manufacturing of micro dimensional spur gear, Processing of ceramic materials, Defects, salvaging techniques and Applications of powder metallurgy.	7
6.	PROCESSING OF PLASTICS: Building of chain from gas to solid, Raw materials for plastics, Polymerization, Types of plastics, Flow process for fabrication and processing of plastics, Calendering's, Rotational, Injection and Blow molding, Helmet and Pepsi type bottle manufacturing; Defects, and salvaging techniques.	5

List of Experiments:		No. of Turns
1	Carpentry section: (i) half lap T & L-joint, (ii) pattern of hexagonal nut.	2
2	Foundry section: (i) mould making, (ii) casting hexagonal nut.	2
3	Fitting & Electroplating: (i) Filing, leveling & surface marking, (ii) buffing and electroplating on sheet metal	2
4	Electrical section: (i) electrical wiring, (ii) electrical connection of bulb, tube, heater.	2
5	Welding section: (i) arc welding: V, L,T joints, (ii) spot welding on sheet metal.	2
6	Automobile Section: (i) study automobile engine, battery connection and study ignition system	2
7	Siemens Automatic Manufacturing Section: (i) Study of robotics, (ii) study of CNC machine, (iii) study of AGMS.	2

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge level (Blooms Level)
1	Understand the concept of manufacturing, product design, selection of raw materials, storing and process planning.	L2
2	Plan and apply the different manufacturing processes to fabricate the ferrous, nonferrous and composite materials.	L3
3	Analyze the possible defects during casting, powder metallurgy, processing of plastics, forming, welding, and ability to rectify the defects.	L4
4	Ability to select and apply the suitable primary manufacturing processes to make desire feature of products.	L3
5	Estimate the pouring and solidification time of metal casting.	L5
6	Design and adapt different gating system, runner and riser to cast product / parts, dies for engineering components.	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	-	1	-	-	-	-	-	1	2	2	1
CO2	3	2	3	1	2	-	-	-	-	-	2	1	3	2
CO3	1	3	1	3	1	-	-	-	-	-	2	2	3	1
CO4	3	3	1	1	2	-	-	-	-	-	2	2	3	2
CO5	3	1	1	3	2	-	-	-	-	-	1	1	3	1
CO6	2	2	3	3	3	-	-	-	-	-	1	1	3	2

Suggested Books

Sr. No.	Name of the Book/ Authors/Publisher	Year of Publication/ Reprint
1	Manufacturing Engineering and Technology; Serope Kalpakjian and Steven R. Schmid, 4th ed., Pearson.	2007
2	Principles of Manufacturing Materials and Processes; Campbell-Tata McGraw Hill.	1999

3.	Fundamentals of Modern Manufacturing, Mikell P. Groover, 5 th ed., Wiley	2013
4.	Material and Processes in Manufacturing, E.P. Degarmo, Ronald A. Kohser, and J. T. Black; Prentice Hall of India	2017
5.	Manufacturing Processes, P.C. Sharma, S. Chand Publication.	2008

Course Name	:	ELEMENTS OF THERMODYNAMICS
Course Code	:	MEN3002
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	Understand the importance of thermodynamics.
2	Basic understanding of various types of thermodynamic systems.
3	Understand the basic principles of thermodynamics systems.
4	Understand the various types of boilers.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	BASIC CONCEPTS: Introduction of thermodynamics, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance, Thermodynamic Properties, Zeroth Law of Thermodynamics, Temperature Scales, Concept of Heat and work in Thermodynamics.	5
2	FIRST LAW OF THERMODYNAMICS: Joule's Paddle Wheel Experiment, Mechanical Equivalent of Heat, First Law thermodynamics for closed and open systems, Different forms of stored Energy, Enthalpy, Energy of an isolated System, Perpetual Motion Machine of First kind. Flow Process, Control Volume, work and Energy Equations, Throttling Process, Non-Flow work.	5
3	STEADY FLOW ENERGY EQUATION (Flow Processes and 1st Law): Flow rate and continuity equation, Flow process and control volume, Flow work or flow energy, Steady and unsteady flow process, Steady flow energy equation (SFEE), Engineering applications of steady flow energy equation, Throttling process, Flow work and non-flow work, Flow work processes.	2
4	SECOND LAW OF THERMODYNAMICS: Limitations of First Law, Second Law of thermodynamics, Heat and Work, Thermal Reservoir, Planck and Clausius statements, Energy Analysis of Heat Engine, Refrigerator and Heat Pump, Reversibility and Irreversibility, Carnot Theorem and cycle, Efficiency of the Reversible Heat Engine, Thermodynamic Temperature scale.	5
5	ENTROPY: Clausius Theorem, Clausius Inequality and concept of Entropy, Entropy: Principle, Entropy generation in closed and open System, Thermodynamics Equations relating properties of System, Reversible Adiabatic work in a Steady flow System, Entropy and disorder.	5
6	AVAILABLE ENERGY AND AVAILABILITY: Available Energy referred to a cycle, Quality of work, Maximum work in Reversible Process, Useful work, Dead State, Availability, Second Law Efficiency.	4
7	GAS POWER CYCLES: Air Standard efficiency, Mean Effective Pressure, Otto, Diesel, Dual, Brayton, Stirling and Ericson Cycle, Comparison of cycles. Equation of state of a gas, Introduction to Two stroke and Four stroke Petrol and Diesel Engine.	4

8	PROPERTIES OF PURE SUBSTANCES: P - v , T - s , h - s , diagram for a Pure Substance, Properties of Pure substance with special reference to water, Steam and its formation, Wet Dry, Saturated and Superheated Steam, sensible, Latent heat, Dryness fraction and its determination, Separating and Throttling calorimeter Enthalpy, Entropy and Internal Energy of Steam, Use of Steam Table and Mollier Diagram, Basic Thermodynamic Processes of Steam in Closed and Open System and their representation on P - V and H - S chart.	5
9	INTRODUCTION TO STEAM GENERATORS/BOILERS: Classification of boilers, fire tube boilers, water tube boilers, comparison between water tube and fire tube boilers, guidelines for the choice of a new boiler, essentials of a good boiler, boiler mountings and accessories.	3
10	VAPOUR POWER CYCLE: Carnot and Rankine Steam Power Cycle, Actual Vapour cycle Processes, Comparison of Carnot and Rankine cycle, Mean Temperature of Heat Addition, Reheat Cycle, Ideal Regenerative Cycle Reheat Regenerative Cycle, Feed Water Heater, Characteristics of an Ideal working fluid in Vapor Power cycle.	4

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand various laws of thermodynamics and their application to various systems.	L2
2	Apply the basics of thermodynamics in various engineering applications.	L3
3	Analyze the performance of vapor and gas power cycles, phase-change processes, and other thermodynamics processes.	L4
4	Examine the close and open thermodynamic systems, and find the optimized solution(s).	L5
5	Analyze and effectively utilize the thermal appliances in day-to-day life.	L4

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Thermodynamics, Gordon Rogers & Yon Machew, Pearson	2006
2	Thermodynamics, Yunus Cengel and Mike Boles, 9 th ed., McGraw Hill	2019
3	Thermodynamics, C. P. Arora, McGraw Hill	2017
4	Engineering Thermodynamics, P.K. Nag, McGraw Hill	2005
5	Thermodynamics, D.S. Kumar, S.K. Kataria & Sons	2013

3														
CO 4	2	3	2	3	-	-	-	-	-	-	-	-	3	1
CO 5	2	3	3	1	-	-	-	-	-	-	-	1	3	1
CO 6	1	1	1	3	-	-	-	-	2	2	-	1	2	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engg. Mechanics of Solids, E.P. Popav, Pearson Education.	2003
2	Mechanics of Materials, FP Beer and R Johnson, Tata-McGraw Hill Publishers, India	2005
3	Mechanics of Materials, Gere, Thomson Books.	2004
4	An Introduction to the Mechanics of Solids, Crandall & Dahl, McGraw Hill.	2012
5	Mechanics of Material, Kirpal Singh, Standard Publisher.	2013
6	Strength of Material, D S Bedi, Khanna Book Publication.	2010
7	Strength of Material, R K Rajput, S Chand Publication.	2012
8	Advanced Mechanics of Solids – L.S. Srinath (Tata McGraw Hill)	2017

Course Name	:	KINEMATICS OF MACHINES
Course Code	:	MEN3004
Credits	:	3
L-T-P	:	2-1-0

Sr. No.	Course Objectives In this course, the student should be able to:
1.	Understand the basics of machines and mechanisms.
2.	Understand the concepts of kinematic diagrams, kinematic chains & mobility, mechanisms and Kinematic analysis.
3.	Study of cam profiles, motion generation, and application in machinery, covering kinematics, dynamics, and practical design considerations
4.	Analysis, design, and application of transmission elements like belts, ropes, and chains in mechanical systems
5.	Understand about types and working of brakes and dynamometers.

Total No. of Lectures - 28

Lectures wise Breakup		No. of Lectures
1	Mechanisms and Machines: Mechanism and machine, Types of constrained motion, Rigid and resistant bodies, Link, Kinematic pair, Types of joints, Degree of freedom, Classifications of kinematic pairs, Kinematic chain, Linkage, mechanism and structure, Mobility of mechanism, Equivalent mechanism, The four-bar chain, Transmission angle, Single slider crank chain and Double slider crank chain.	4

2	Velocity Analysis: Absolute and relative motions, Motion of a link, Four-link mechanism, Velocity images, Angular velocity of links, Velocity of rubbing, Slider crank mechanism, crank and slotted lever mechanism, Instantaneous centre (I-Centre), Kennedy's theorem, Locating I-Centres, Angular velocity ration theorem and Centrode.	4
3	Acceleration analysis: Acceleration, Four link mechanism, Acceleration of intermediate and offset points, Slider crank mechanism, Coriolis acceleration components, Crank and slotted lever mechanism, Algebraic method, Kleins construction and Velocity and acceleration from displacement time curve.	4
4	Cams: Types of cams, Types of followers, Definitions, Follower displacement programming, Derivations of follower motion, High-speed cams, Undercutting, Motions of followers and Layout of cam profiles	5
5	Belt, Rope and Chains: Belt and rope drives, Open and cross belt drive, Action of belts on pulleys, Velocity ratio, Slip, material for Belts and ropes, Crowning of pulleys, Types of pulleys, law of belting, Length of belt, Cone (Stepped) pulleys, Ration of friction tensions, Power transmitted, Centrifugal effects on belts, Maximum power transmitted, Centrifugal effects on belts, Maximum power transmitted by belt, Initial tension, Creep, Chains, Chain Length, angular speed ratio and Classification of chains.	5
6	Brakes and Dynamometers: Types of brakes, Block or shoe brakes, band brakes, Band and block brakes, Internal expanding shoe brake, Effect of braking, Types of dynamometers, Prony brake dynamometer, Rope brake dynamometer, Hydraulic dynamometer, Belt transmission dynamometer, Epicyclic train dynamometer and Bevis Gibson torsion dynamometer.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1.	Identify common mechanisms used in machines and everyday life and determine the mobility (number of degrees-of-freedom) of planar structures, and mechanisms.	L1 & L3
2.	Perform complete translational and rotational mechanism velocity analysis and acceleration analysis.	L3 & L4
3.	Construct and analyze cam profiles for a specified motion of the follower	L6
4.	Understand and evaluate various power transmission elements for their kinematic domain.	L2, L5
5.	Determine frictional torque and power in brakes and dynamometers and their applications in mechanical systems.	L2

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Theory of Machines, V.P. Singh, Dhanpat Rai & Co. Pvt. Ltd, New Delhi.	2014
2.	Theory of Machines, P.L. Ballaney, Khanna publishers, New Delhi.	1994
3.	Theory of Machines, Shigley, Tata McGraw Hill.	1981
4.	Mechanism & Machine Theory, J.S. Rao & R.V. Dukhipati, Wiley Eastren Ltd.	1992
5.	Theory of Mechanisms, Amitabh Gosh & A.K. Mallik, East West Press Machines Private Ltd.	2008
6.	Theory of Machines, S. S. Rattan, McGraw Hill Education (India)	2019

Course Name	:	PHYSICAL METALLURGY AND HEAT TREATMENT
Course Code	:	MEN3005
Credits	:	3
L T P	:	3-0-0

Course Objective:	The course aims to impart the fundamental knowledge about:
1.	Understanding the crystal structure and microstructures of metals and alloys, including solid solutions and multiple phase alloys.
2.	Understanding the principles behind the mechanical behavior of metals and alloys in terms of dislocation motion.
3.	Phase-diagrams, Iron-Carbon diagram.
4.	Becoming familiar with the properties of ferrous and non-ferrous metals, composites and polymeric materials that will help to select the materials for various engineering applications
5.	Heat treatment cycles and their applications to modify the properties of metallic and non-metallic materials.

No. of Lectures - 42

Lecture wise breakup		No. of Lectures
1.	INTRODUCTION TO CRYSTALLOGRAPHY: Bonding in solids: ionic, amorphous, and crystalline, unit cell, Bravais lattice, atomic arrangements in solids, space lattices, coordination number, effective number of atoms, stacking sequence and atomic packing factor for common crystalline structures: FCC, BCC and HCP, indexing of crystallographic planes and directions. linear and planer densities	4
2.	STRUCTURAL IMPERFECTIONS: Point defects: vacancies, self interstitiality, impurities, Frenkel and Schottky defect, line defect: edge and screw dislocations, surface defects: grain boundaries, low angle boundaries, twin boundaries, and stacking faults, volume defects	4
3.	ALLOYS AND PHASE DIAGRAMS: Constitution of alloys, Solid solutions, substitutional and interstitial, phase diagrams, Isomorphism, eutectic, eutectoid, peritectic, and peritectoid reactions, cooling curves, unary & binary phase diagrams, Gibbs's phase rule, Lever rule, Iron-carbon equilibrium diagram	6
4.	DEFORMATION OF METALS Elastic and plastic deformation, mechanism of plastic deformation, twinning, conventional and true stress strain curves for polycrystalline materials, yield point phenomena, strain ageing, work hardening, Bauschinger effect, season cracking. Recovery, re-crystallization and grain growth.	6

5.	FERROUS AND NON-FERROUS METALS: Classification of ferrous and non-ferrous metals, Cast-iron microstructure, properties and application. Effect of alloying elements on properties of steels, α and β stabilizers, stainless and tool steels, HSLA, OHNS, Grey, white, malleable, nodular cast iron, spheroidal cast irons, Copper and copper alloys: Brass, Bronze and Cupronickel, Al and Al-Cu, precipitation strengthening treatment, white metal, bearing alloys, Mg-alloys, Ag and its alloys, Zn and its alloys, Ni-based super alloys, Ni-Cr alloys, Inconel, monel, Titanium alloys, applications	5
6.	MATERIAL PROPERTIES AND TESTING Hardness test (Brinell, Vickers, and Rockwell), Testing of materials under tensile, compressive and shear loads, impact test (Charpy and IZOD), Fatigue test: S-N curve, methods of improving fatigue life, Creep test: creep curve, creep fracture, material consideration for high temperature use.	6
7.	HEAT TREATMENT: Definition, objectives, classification; annealing, spheroidizing, normalizing, hardening, tempering, nitriding, carburizing, flame and induction hardening, cyaniding, boronizing, Isothermal transformation, T-T-T curve and austempering of steel, cooling curves superimposed on I.T. diagram, CCR, Hardenability, Jominy end quench test, Martempering, Vacuum and Plasma hardening.	6
8.	CERAMIC, COMPOSITES, AND POLYMERS Ceramics: types of ceramics, fabrication and processing of ceramics: (i) glass forming processes (ii) particulate forming processes (iii) cementation, Composites: advantages of composites, constituents of composites, applications of composites, classification of composites: based on matrix and reinforcement, Polymers: hydrocarbon and polymer molecules, molecular shape and structure, molecular configuration, thermoplastic and thermosetting polymers.	5

Sr. No.	Course outcomes: The students will be able to:
1	Identify and interpret the properties of metals with respect to crystal structure and grain size.
2	Classify and distinguish different types of steels, cast irons, non-ferrous alloys and ceramic materials
3	Know the mechanical properties of materials and will be able to choose a suitable material for a particular engineering application.
4	Know about the Iron-carbon phase diagram and the characteristics features of various phases of steel and cast iron.
5	Describe the heat treatment processes, mechanism of phase transformation and effect of heating and cooling rate on phase transformation and mechanical properties.

CO-PO & PSO course Articulation Matrix

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

Sr. No.	Name of the Book/ Authors/Publisher	Year of Publication/ Reprint
1	Material Science and Engineering: An Introduction/ William D. Calister/ John Wiley and Sons	2007
2	Materials Science and Engineering/ William F Smith, Javed Hashemi, Ravi Prakash	2008

	/Tata McGraw Hill,	
3	Mechanical Behaviour of Materials /Thomas H. Courtney/ McGraw Hill,	2015
4	Heat Treatment: Principles and Techniques/TV Rajan, CP Sharma/PHI Learning	2023

Course Name	:	FLUID MECHANICS
Course Code	:	MEN3006
Credits	:	3
L T P	:	2-1/2-2/2

Course Objectives:	
1	To understand the basic concept of fluid mechanics.
2	To understand statics, dynamics and various approaches to fluid mechanics.
3	To correlate fundamentals of fluid mechanics with various mechanical systems
4	To understand basic concepts of the boundary layer theory and turbulence

Total No. of Lectures –28

Lecture wise breakup		No. of Lectures
1	Introduction: Basic Concepts and Definitions, Properties of Fluid, Viscosity, Capillarity, Surface Tension, Compressibility, Normal and Shear Stresses in Fluid Flows.	3
2	Fluid Statics: Types of Forces on Fluid Element, Mechanics of Fluid at Rest and in Rigid Body Motion, Manometry, Hydrostatic Forces on Fully and Partially Submerged Bodies, Stability of a Floating Body.	4
3	Kinematics of Fluid Flow: Lagrangian and Eulerian Methods, Description of Properties in a Moving Fluid, Local and Convective Acceleration, Streamlines, Path Lines, Streak Lines, Acceleration and Rotation of a Fluid Particle, Vorticity and Circulation, Stream Function, Velocity Potential Function.	4
4	Dynamics of Fluid Flow: Basic Physical Laws of Fluid Mechanics, The Reynolds Transport Theorem, Equation of Conservation of Mass, Differential Form of Continuity Equation, Navier-Stokes Equations, Euler's Equation of Motion, Frictionless Flow - Bernoulli's Equation, Applications to Flow Measurement and other Real Flow Problems	4
5	Viscous Flow: Regimes of Flow, Pressure Gradient in Steady Uniform Flow, Qualitative Aspects of Viscous Flows, Exact solutions of Navier-Stokes Equations, Laminar Flow Through a Pipe - Hagen-Poiseuille's Flow, Transition from Laminar to Turbulent Flow, Turbulent Flow Through a Pipe, Friction Factor, Applications to Pipe Networks.	5
6	Flow Past Immersed Bodies: Reynolds Number and Geometry Effects, Momentum Integral Estimates, Boundary Layer (BL) Equations, Flow Over a Flat-Plate, Boundary Layers with Pressure Gradients, Laminar and Turbulent BL, Separation of BL and Control of Flow Separation, Streamlined and Bluff Body.	5
7	Dimensional Analysis and Similitude: Buckingham's Theorem, Non-Dimensional Groups, Geometric, Kinematic and Dynamic Similarity, Modeling of Fluid Flows, Applications.	3

List of Experiments:		No. of Turns
1	To determine the metacentric height of a given vessel under unloaded condition.	1
2	Verification of Bernoulli's theorem and measurement of velocity using Pitot tube.	2
3	To determine the Coefficient of discharge through Venturi meter and Orifice meter.	2
4	To determine the different types of flow Patterns by Reynolds's experiment.	1
5	To determine the Friction factor and loss coefficients for the different pipes.	1

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic concept of fluid mechanics.	L2
2	Apply the principles of fluid statics and dynamics to real life problems.	L3
3	Correlate and implement the fundamentals of fluid mechanics to analyze simple hydrodynamics systems.	L4
4	Examine the basic fluid flow problems through analytical tools.	L5
5	Introduction to the concept of boundary layer and its implementation to solve practical fluid flow problems.	L4

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fluid Mechanics by Frank .M. White, McGraw Hill Publishing Company Ltd.	2017
2	Fluid Mechanics and Fluid Power Engineering by D.S. Kumar, S.K. Kataria & Sons	2013
3	Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Publications	2023
4	Fundamentals of Fluid Mechanics by Munson, Wiley India Pvt. Ltd, 7 th edition	2015
5	Fluid Mechanics: Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala, McGraw Hill Education; 4 th edition	2019

Course Name	:	MANUFACTURING PROCESSES
Course Code	:	MEN4001
Credits	:	4
L T P	:	3-0-2

Sr.No.	Course Objectives:
1.	To impart the knowledge of machine tools, cutting tools and tooling system used in metal cutting.
2.	To impart the knowledge of press tools and dies, and their applications in the manufacturing processes.
3.	To impart the knowledge of design of jig and fixture, their application to locate and hold the component, and proper clamping.
4.	To impart the knowledge of advanced non-conventional and hybrid machining techniques and their applications for processing of conductive and non-conductive materials.
5.	To impart the knowledge of rapid prototyping methods, rapid product development technique and its applications.

No. of Lectures - 42

Lecture wise breakup		No. of Lectures
1.	<p>MACHINE TOOLS: All types of Lathes, Shaper, Slater, Planar, Milling, Drilling, Grinding, Broaching, Sawing machines: Principle, components, applications.</p> <p>CNC Machines: Type, Specification, Components of CNC machines, Open and close loop control system, G-codes and M-codes, CNC part programming, Applications.</p>	6
2.	<p>METAL CUTTING: Single and Multipoint cutting tools; Tool geometry, True rake and shear angles, Fundamental of metal cutting: orthogonal and oblique cutting, Cutting fluids and application; Mechanism of chip formation; Classification and types of chips, Chip formation in drilling and milling; Chip breaker, Merchant force diagram; Force analysis during turning and drilling; Tool wear, failure and tool life; Design of form tool; Machinability, Thermal and Economics aspect of metal cutting, Advanced cutting tools and materials; Manufacturing of cutting tools,</p>	10
3.	<p>JIGS AND FIXTURES: Definition, significance, classification, degrees of freedom, principle of locating elements and clamping, clamping devices, drill bushes; Design of jigs and fixtures; Jigs and fixtures for milling, drilling, grinding.</p>	6
4.	<p>PRESS TOOLS AND DIES: Press working equipment's and tools; Types of dies, components of cutting die; Mechanism and techniques of reducing cutting forces. Blanking, Piercing, Drawing, Bending, and Forging die design. Design of die blocks, punches and strippers; Strip layout, die materials, Advance processes for die manufacturing.</p>	7
5.	<p>NON-CONVENTIONAL AND HYBRID MACHINING PROCESSES: Objectives, USM, AJM, CH, ECM, Electrochemical grinding, deburring and honing, EDM, WEDM, LBM, EBM, ECSM, TWECM, LAECM: working principle, Process description, performance characterization, parametric effect, capabilities, limitations and applications. Introduction to micro machining, micro-turning, micro-milling, micro-drilling, micro EDM, micro-ECM. Introduction to advance finishing process: AFM, EEM, CMP, and applications.</p>	8
6.	<p>RAPID PROTOTYPING: Classifications, types, principles and advantages of rapid prototyping. Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS), Stereolithography (SLA), Laminated object manufacturing (LOM): parameters, factors effecting the responses of rapid prototyping, Accuracy, Economic, and Applications.</p>	5

List of Experiments		No. of Turns
1	CNC programming and machining operations: To develop the part programme for turning, taper turning, thread cutting.	3
2	Gear cutting on Milling machine.	2
3	Analysis of tool wear using stereo-zoom and metallurgical microscope.	1
4	Study the process parameters and experimental setups of EDM and Wire EDM processes.	2
5	Drilling micro holes in hard to machine materials using Fast drill EDM setup.	2
6	Fabrication of plastic components using Injection molding setup.	2
7	Study and development of products using FDM based 3D printing.	2

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms)

		Level)
1	Clear the basic concept of machine tools, cutting tools and tooling system used in metal cutting	L1
2	Outline the basic concepts and understanding about the orthogonal and oblique cutting, chip formation, failure of cutting tool and tool life. .	L2
3	Knowledge of advanced non-conventional and hybrid machining techniques and their applications for processing of conductive and non-conductive materials.	L3
4	Outline the basic concept micro machining processes and rapid prototyping, CNC programing, and analysis of tool wear.	L4
5	Design of jig and fixture, locate and hold the component, proper clamping and their applications	L5
6	Design of press tools and dies, and their applications in the manufacturing processes and formulate the ideas with innovative concepts for developing advanced machining setup, tool and tooling system,	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	2	2	-	-	1	-	-	-	-	1	3	1
CO3	3	2	2	3	2	-	1	-	-	-	-	1	3	2
CO4	2	3	2	3	2	-	2	-	-	-	2	1	3	3
CO5	3	2	2	3	2	-	-	-	-	-	1	2	2	2
CO6	3	3	2	1	1	-	-	-	-	-	1	2	3	2

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Manufacturing Engineering and Technology, Serope Kalpakjian and Steven R. Schmid- 4 th ed., Pearson Edition.	2013
2	Manufacturing Science, Amitava Ghosh and Asok Kumar Mallik, East-West Press Pvt Ltd., New Delhi.	1993
3	Advance Machining Processes, V K Jain; Allied publishers, New Delhi.	2009
4	Manufacturing Processes, B.S. Raghuvanshi, Publisher, Dhanpat Rai & Co. (P) Ltd	2020

Course Name	:	APPLIED THERMODYNAMICS
Course Code	:	MEN4002
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To develop an understanding of thermodynamics as it applies to real systems.
2	To develop problem-solving skills through the application of thermodynamics and the use of lab studies to reinforce knowledge gained in theory classes.
3	To introduce students to the various conventional applied thermal systems, such as IC Engines, Compressors, Turbines, Condensers, Nozzles, and Diffusers.
4	To analyze, optimize, and design newer thermodynamics systems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	I.C. ENGINES: Introduction to IC Engines, Classification of IC engines, Engine parts and their functions, Valve timing diagrams, Combustions in CI and SI Engines, Cooling System, Lubrication system, Performance analysis of IC Engines, Performance curves for CI and SI engine, Measurement of Indicated Power and Brake Power, Performance Parameters, Morse Test, Heat balance sheet and Performance Characteristics.	8
2	RECIPROCATING COMPRESSOR: Introduction, classification of air compressors, work input and the best index of compression, thermal and polytropic efficiency of the compressor, Effect of clearance and volumetric efficiency, multi-stage compression and its advantages.	4
3	CENTRIFUGAL COMPRESSOR: Principle of operation, components of a centrifugal compressor complete thermodynamics analysis of centrifugal compressor stage, isentropic and Isothermal efficiencies, work done and pressure rise, Velocity vector diagrams for centrifugal compressors and power calculation, pre-guide vanes and pre-whirl, slip factor, power input factor, degree of reaction and its derivation, energy transfer in backward, forward and radial vanes.	5
4	AXIAL FLOW COMPRESSOR: Component of axial flow compressor and their arrangement, Principle of operation, velocity vector diagrams, thermodynamics analysis, and power calculation, Factors affecting stage pressure rise, work done factor, Degree of reaction and blade Efficiency and their derivation, Isentropic, Polytropic, and isothermal efficiencies, Surging, choking and stalling in axial flow compressors, Characteristics curve for axial flow compressors.	4
5	STEAM TURBINES: Introduction, General description of Impulse and Reaction steam turbines, <i>Impulse Turbine:</i> General description, pressure and velocity compounding, Velocity diagram and work done, Blade efficiency and overall efficiency Reheat factor and condition curve, <i>Reaction Turbine:</i> Degree of reaction, Velocity diagrams, blade efficiency, and its derivation, Losses in steam turbines, Stage efficiency, Overall efficiency, and Reheat factor, various types of steam governing like throttle governing, nozzle control governing and bypass governing.	8
6	GAS TURBINES: Introduction, classification of gas turbines based on a system of operation and based on combustion (at constant volume or constant pressure), Thermodynamics of constant pressure gas turbine cycle, calculation of net output, work ratio, and thermal efficiency of ideal and actual cycles. Thermal refinements and their effects on the gas turbine cycle, i.e., gas turbine cycle with regeneration, intercooling and reheating, multistage compression, and expansion.	7
7	NOZZLES AND DIFFUSERS: Types and utility of nozzles, Flow of steam through nozzles, Effect of friction, Nozzle efficiency, Critical pressure conditions for maximum discharge, Supersaturated flow, Classification of diffusers, the effect of friction and area change, converging-diverging super-sonic diffuser.	3
8	CONDENSERS: Introduction, Elements of condensing plants, Brief description of different types of condensers, Dalton's law of partial pressure applied to condenser problems, condenser and vacuum efficiencies, Cooling water calculations, Effect of air leakage, Method of checking and preventing air infiltration, Description of air pump and calculation of its capacity.	3

List of Experiments:		No. of Turns
1	To study the construction and operation of a two-stroke and four-stroke petrol and diesel engine	1

2	To study the valve timing diagram for a Diesel Engine.	1
3	To find the Volumetric Efficiency, Brake Thermal Efficiency Mechanical Efficiency, Frictional Power, Indicated Power Heat Balance sheet of Variable Compression Ratio Engine at different Compression Ratios and study its effect on various parameters.	1
4	To estimate the Indicated Power, Friction Power, and Mechanical Efficiency of a multi-cylinder Petrol Engine when running at a constant speed under constant settings of a carburetor by cutting the power of one cylinder each in turn (Morse test).	1
5	To study the Cochran Boiler and its mounting and accessories.	1
6	To study Fraser Boiler and its mounting and accessories.	1
7	To study the thermal power plant and its working.	1
8	To Study two-stage reciprocating compressor.	1
9	To study window-type air conditioners and split air conditioners.	1
10	To study and draw the vapor compression cycle for a Refrigeration test rig under different variables.	2
11	To draw the fundamental vapor compression cycle for the window AC test rig and calculate its COP and cooling capacity.	2

Course outcomes: By the end of this course, the student will be able to:		Knowledge Level (Blooms Level)
1	Develop problem-solving skills through the application of thermodynamic principles.	L2
2	Develop a basic understanding of various devices like engines, compressors, turbines, compressors, etc.	L3
3	Understand the different components of IC Engines through lab-scale experiments.	L4
4	Optimize the existing thermal system and design newer ones, as per requirements.	L5
5	Propose changes in the existing thermal system and formulate new ones.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Heat Engineering, Vasandani and Kumar, Metropolitan Co. Pvt. Ltd., Delhi.	2013
2	Thermal Engineering, P. L. Ballaney, Khanna Publisher Delhi.	2005
3	Applied Thermodynamics, R. Yadav, Central Publishers, Allahabad.	2011
4	Applied Thermodynamics for Engineering Technologists, T D Eastop and A McConkey, 5 th Ed., Pearson.	2017
5	Basic and Applied Thermodynamics, P.K. Nag, 2 nd Ed, Tata McGraw-Hill.	2017

Course Name	:	REFRIGERATION AND AIR-CONDITIONING
Course Code	:	MEN4003
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To understand the basic principles of Refrigeration & Air Conditioning Systems.
2	To learn the working and understand the construction of the various components of Refrigeration System like evaporators, compressor etc.
3	To design air conditioning system for practical applications.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	REFRIGERATION: Refrigeration effect, cooling capacity and C.O.P. of a refrigerator, E.P.R. of heat pump, Reversed Carnot Cycle	4
2	AIR CYCLE REFRIGERATION: ANALYSIS OF BELL COLEMAN CYCLE: Need of aircraft refrigeration and air conditioning; Analysis of different Air Cycle Refrigeration Systems for aircraft.	4
3	VAPOUR ABSORPTION REFRIGERATION: (Only Introduction: No Derivation) Simple vapour absorption refrigeration; Modifications to simple vapour absorption refrigeration system; Actual vapour absorption refrigeration system; Electrolux system; Lithium Bromide; Water absorption refrigeration system; Solid -Vapour absorption and absorption refrigeration system.	4
4	VAPOUR COMPRESSION REFRIGERATION: Vapour compression Cycle on P-V, P-H and T-S diagrams; Deviation of actual Cycle from theoretical one; Mathematical analysis of theoretical and actual vapour compression refrigeration cycle; effect of suction pressure, discharge pressure, sub-cooling, superheating, and pressure drop in valves.	5
5	MULTI-PRESSURE VAPOUR COMPRESSION REFRIGERATION: Single load compound compression with single expansion and water intercooling; single load compound compression with individual expansion valve and flash intercooling; Multiple load systems with individual expansion valves and individual compressors; Single Load Compound Compression with flash tank and water intercooling; Single Load Compound with flash chamber as intercooler.	5
6	NON-CONVENTIONAL REFRIGERANT SYSTEMS: Steam Jet Refrigeration; Cascade Refrigeration System; Mixed Refrigeration System; Vortex Tube Refrigeration; Thermoelectric Cooling, Modern Air Condition Systems like HVAC, Variable refrigerant volume (VRV/VRF)	4
7	CRYOGENICS: Definition, Cryogenic fluids, storage and insulation; Linde-Hampson and Claude Liquification Cycles (NO ANALYSIS); Adiabatic Demagnetization; Applications.	4
8	PSYCHOMETRY: Definition, Applications; Psychometric properties of air; Dry bulb, wet bulb and dew point temperatures; Relative and specific humidity; Enthalpy of air and water vapours; Human requirements of comfort; Effective temperature.	4
9	BASIC PROCESSES IN CONDITIONING OF AIR Sensible cooling and heating of air; simple humidification and dehumidification of air concept of bypass factor; cooling and dehumidification; Evaporative cooling; chemical dehumidification; air washer.	4

10	LOAD CALCULATIONS AND SUPPLY AIR CONDITIONS: Sources of heat load; sensible and latent heat load; sensible heat factor; apparatus dew point temperature; quality and state of supply air for air conditioning of various buildings; Load calculations for comfort and cold storage air conditioning.	4
----	--	---

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic concepts of refrigeration, refrigeration systems, and environmental impact of refrigerants.	L2
2	Apply the laws of thermodynamics to solve various refrigeration and air conditioning problems.	L3
3	Analyze and determine the performance of vapor compression cycle under different operating conditions.	L4 & L5
4	Understand the principles of non-conventional refrigeration system.	L2
5	Develop understanding of psychometric properties and chart, determine cooling load and design the air conditioning systems.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Refrigeration and Air Conditioning, Jordon and Priester, Prentice Hall of India	2009
2.	Principles of Refrigeration, R.J. Dossat, Wiley Eastern	2001
3.	Refrigeration and Air Conditioning, C.P. Arora, Tata McGraw Hill	2017
4.	Refrigeration and Air Conditioning, Manohar Prasad, New Age International (Pvt.) Ltd., Publishers.	2010
5.	Refrigeration and Air Conditioning, P.L. Ballaney, Khanna Publishers	2012
6.	Refrigeration & Air-conditioning, R. S. Khurmi, S. Chand	2019

Course Name	:	MECHANICAL VIBRATIONS
Course Code	:	MEN4004
Credits	:	4
L T P	:	3-1/2-2/2

Course Objectives: In this course, the student should be able to understand the	
1	Causes, sources and the basic principles of mechanical vibrations.
2	Mechanical Vibration concepts to one, two, multi and infinite degree of freedom systems with different systems components.
3	Concept of numerical methods applicable to study vibration in any engineering system design.
4	Concepts of modal analysis in study of vibrations.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	INTRODUCTION: Basic concept of vibration, Importance and scope, definition and terminology, representation and analysis of harmonic motions, beat phenomenon, work done by a harmonic force on an harmonic motion, Analytical method for Fourier series and Harmonic analysis, introduction to various types of vibrations and types of excitation.	4
2	SINGLE DEGREE OF FREEDOM UNDAMPED FREE VIBRATIONS SYSTEMS: Derivation of differential equation of motion by D' Alembert's principle, Energy method, Rayleigh method, Newton's second law of motion, Solution of the equation, equivalent spring stiffness of system of springs, Applications of the above concepts to various problems.	4
3	SINGLE DEGREE OF FREEDOM DAMPED FREE VIBRATIONS SYSTEMS: Introduction to viscous damping, sub-critical, critical and over-damping systems for free vibration and its solutions, logarithmic decrement, frequency of damped oscillations; Dry friction damping and its frequency and rate of decay per cycle, Concept of eddy current damping, Structural damping and Slip damping.	6
4	SINGLE DEGREE OF FREEDOM FORCED VIBRATIONS SYSTEMS: Various types of forcing function in force vibration, Force vibration analysis with constant harmonic excitation, rotating & reciprocating unbalance masses, due to excitation of the support, Determination of equivalent viscous damping and system identification from frequency response curve, Vibration isolation and transmissibility, vibration measuring instruments	7
5	TWO DEGREE OF FREEDOM SYSTEMS: Principal mode of vibration, normal modes, nodes, natural frequencies, mode shapes for two degree of freedom system having undamped and damped element in it, Application of the above to various systems like torsional vibrations of two rotor systems, strings, double pendulum etc., application of Two degree of freedom in dynamic vibration absorber and Torsional vibration absorber, centrifugal pendulum absorber.	7
6	MULTI-DEGREE OF FREEDOM SYSTEMS - EXACT ANALYSIS Undamped free vibrations, Influence coefficients and Maxwell reciprocal theorem, Matrix Inversion method and determination of eigen values & eigen vectors, torsional vibrations of multi rotor system; Continuous systems, vibration of string, longitudinal vibrations of bar, transverse vibration of beam, torsion of vibrations of circular shaft under various end conditions.	7
7	MULTI-DEGREE OF FREEDOM SYSTEMS - NUMERICAL METHOD Orthogonal properties of normal modes, Matrix Iteration and determination of all the eigen values & eigen vectors, Rayleigh methods, Dunkerley method, Stodola method, Holzer methods as applied to multi degree of freedom systems and determination of Eigen-values & Eigen-vectors, characteristic equation and comparison of natural frequencies by these methods	7

List of Experiments:		No. of Turns
1	To determine the mass movement of inertia of a body using trifilar suspension.	1
2	To determine the periodic time period of undamped torsional vibration of a single rotor shaft system.	1
3	To determine the stiffness of a helical spring by three different methods and compare the results.	1
4	To study the damped torsional vibrations and determine the torsional damping coefficient.	1

5	To study and determine the periodic time period of free vibration of equivalent spring mass system.	1
6	To study and determine the periodic time period of force vibration of equivalent spring mass system.	1
7	To determine the natural frequency of cantilever beam using DAQ system.	1

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand & apply the concept of Mechanical Vibration in engineering and applied sciences problems in general.	L2 & L3
2	Apply the concept of Mechanical Vibration to one, two, multi and infinite degree of freedom systems with different systems components.	L3
3	Evaluate any mechanical system for its dynamic characteristics.	L5
4	Develop the dynamic model of real-life problems and determine the natural frequencies and mode shapes.	L6
5	Compare different numerical and exact techniques to analyze multi- degree freedom system.	L2 & L4
6	Conduct various tests on machine to assess their dynamic characteristics.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	-	-	1	3	1
CO2	3	3	2	1	-	-	-	-	-	-	-	1	3	1
CO3	2	3	3	1	-	-	-	-	-	-	-	-	2	1
CO4	2	3	3	1	-	-	-	-	-	-	-	1	3	1
CO5	3	3	2	2	-	-	-	-	-	-	-	-	2	1
CO6	1	1	1	3	-	-	-	-	2	2	-	2	3	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechanical Vibrations, G. K. Grover, Nem Chand & Bros, Roorkee	2009
2	Mechanical Vibrations, S. S. Rao, Pearson Education Inc.	2017
3	Mechanical Vibrations, V. P. Singh, Dhanpat Rai & Sons, Delhi	2020
4	Theory and Practice of Mechanical Vibrations, J. S. Rao & K. Gupta, New Age International (Pvt.) Ltd., New Delhi	2002
5	Fundamental of Vibration, Balachandran and Magrab, Cengage Learning	2009
6	Mechanical Vibration & Noise Engineering, A. G. Ambekar, PHI	2006
7	Mechanical Vibration, D. Nag Wiley.	2012

Course Name	:	DYNAMICS OF MACHINES
Course Code	:	MEN4005
Credits	:	4
L-T-P	:	3-1/2-2/2

Sr. No.	Course Objectives
	In this course, the student should be able to:
1.	Understand the static and dynamic force analysis to analyse the forces and motions of systems.
2.	Understand various types of gears and gear trains.

3.	Develop knowledge of analytical and graphical methods for calculating balancing of rotary and reciprocating masses
4.	Understand gyroscopic principles and applications in stability and navigation.
5.	Study the various type of governors and their role in maintaining constant engine speeds and system stability.

Total No. of Lectures - 42

Lectures wise Breakup		No. of Lectures
1.	Static Force Analysis: Constraint and applied forces, Static equilibrium, Equilibrium of two forces and torque, Equilibrium of four forces member, Force convention, Free body diagram, Superposition, Principle of virtual work and Friction mechanisms.	5
2.	Dynamic Force Analysis: D'Alembert's principle, Equivalent offset inertia force, Dynamic analysis of four-link mechanism, Dynamic analysis of slider crank mechanism, Velocity and acceleration of piston, Angular velocity and angular acceleration of connecting rod, Engine force analysis, Turning moment on the crankshaft, Dynamically equivalent system, Inertia of connecting rod, Inertia force in reciprocating engines (Graphical method), Turning moment diagram, Fluctuation of energy, Flywheels, Dimensions of flywheel rims and Punching presses.	8
3.	Gears: Classification of gears, Gear terminology, Law of gearing, Velocity of sliding, Forms of teeth, Cycloidal profile teeth, Involute profile teeth, Involute profile teeth, Path of contact, Arc of contact, Contact ratio, Interference in involute gears, Minimum number of teeth, Undercutting, Comparison of cycloidal involute tooth forms, Helical and spiral gears, Terminology, of helical gears, Worm and worm gears, Velocity ratio and centre distance of worm gears, efficiency of worm gears and Bevel gears.	5
4.	Gear Trains: Simple gear train, Compound Gear train, Reverted gear train, Planetary or epicyclic gear train, Sun and planet gear, Compound epicyclic gear, Automotive transmission gear train and differentials.	6
5.	Balancing: Static balancing, Dynamic balancing, Transference of a force from one plane to another, and Balancing of several masses in different planes. Force balancing of linkages, balancing of reciprocating mass, balancing of locomotives, Effects of partial balancing in locomotives and Secondary balancing, Balancing of Inline engine.	8
6.	Gyroscope: Angular velocity, Angular acceleration, Gyroscope torque, Gyroscope effect on aeroplanes, Gyroscope effect on naval ships, Stability of automobiles, Stability of two-wheel vehicles and Rigid disc at an angle fixed to a rotating shaft.	5
7.	Governors: Types of governors, Watt governor (Simple conical governors), Porter governor, Proell governor, Hartnell governor, Hartung governor, Wilson-Hartnell governor, Pickering governor, Spring-Controlled gravity governor, Inertia governor, Sensitiveness of governor, hunting, Isocronism, Stability, Effort of governor, Power of governor, and Controlling force.	5

List of Experiments:		No. of Turns
1	To find displacement, velocity and acceleration of slider in a single slider crank mechanism for different crank angles and draw various graphs.	1
2	Verify experimentally the gyroscopic couple is given by $T = I\omega\omega_p$	1
3	Draw experimentally the approximate straight line be watts mechanism.	1
4	Find out the positions of the four weights, so that the system becomes statically & dynamically balanced.	1

5	Find the moment of inertia of a given body about an axis passing through C.G. and perpendicular to the plane of the body also calculate the minimum oscillation of the point of suspension.	1
6	Balance experimentally as far as possible the known unbalanced force due to a rotating weight by introducing two balancing weights in two different planes (a) Balancing planes on either side of unbalanced force (b) Balancing planes on the same side of unbalanced force.	1
7	Determination of characteristics curve of the Watt, Porter, Proell and Hartnell Governors using universal governor set up.	1

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1.	Apply the principles of statics and dynamics to analyze mechanisms to determine joint forces and torques.	L3
2.	Analyze dynamic force analysis of slider crank mechanism and design of flywheel.	L4, L6
3.	Analyze and develop gear trains required for various applications.	L4
4.	Evaluate the balancing masses and their positions in rotary and reciprocating systems.	L5
5.	Understand gyroscopic principles and their diverse applications in stability and navigation.	L2 & L3
6.	Identify and analyze the various types of governors used in engineering systems.	L1 & L4
7.	Ability to conduct various tests on machine & mechanism to assess their output characteristics.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	-	-	1	3	1
CO2	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	2	3	2	1	-	-	-	-	-	-	-	1	2	1
CO4	1	1	2	1	-	-	-	-	-	-	-	1	2	1
CO5	1	1	1	3	-	-	-	-	2	2	-	1	3	2
CO6	2	3	2	1	-	-	-	-	1	1	-	2	2	3
CO7	2	3	3	2	1	-	-	-	2	1	-	1	2	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Theory of Machines, V.P. Singh, Dhanpat Rai & Co. Pvt. Ltd, New Delhi.	2014
2.	Theory of Machines, P.L. Ballaney, Khanna publishers, New Delhi.	1994
3.	Theory of Machines, Shigley, Tata McGraw Hill.	1981
4.	Mechanism & Machine Theory, J.S. Rao & R.V. Dukhipati, Wiley Eastren Ltd.	1992
5.	Theory of Mechanisms, Amitabh Gosh & A.K. Mallik, East West Press Machines Private Ltd.	2006
6.	Theory of Machines, S. S. Rattan, McGraw Hill Education (India)	2019

Course Name	:	PRODUCTION & OPERATIONS MANAGEMENT
Course Code	:	MEN5001
Credits	:	3
L T P	:	3-0-0

Course Objectives:	
1.	To impart the knowledge on the concept and significance of Production Management and Capacity planning.
2.	To impart the knowledge on the plant layout design heuristics/algorithms and applications of forecasting techniques.
3.	To impart the knowledge on the Scheduling and Inventory control methods.
4.	To impart the knowledge on applications of PERT and CPM techniques and concepts of Reliability and maintenance.

Total No. of Lectures – 42

Lecture wise breakup		No. of lectures
1	INTRODUCTION TO PRODUCTION MANAGEMENT: Types of Production Systems, Product Design and development, Standardization and simplification, Make-buy decision, Concurrent Engineering and SCM.	5
2	PLANT LOCATION & LAYOUT: Mathematical Models for single facility location, Euclidean and Rectilinear methods and Minimum location problem, Layout Design Heuristics/algorithms: CRAFT, ALDEP and CORELAP, Types of layouts	6
3	FORECASTING: Time Series Analysis: Correlation and regression, Exponential Smoothing, Decomposition algorithm for seasonal data, Measuring and analysis of forecasting accuracy.	6
4	PLANT CAPACITY AND SCHEDULING: Plant capacity and capacity planning strategies, Scheduling and sequencing techniques in job and mass production.	6
5	MATERIALS MANAGEMENT AND INVENTORY CONTROL: Methods, Principles and Need of Inventory control, EOQ Probabilistic and deterministic models, Materials Requirement Planning and MRP-II.	6
6	PROJECT MANAGEMENT: PERT and CPM networks, Critical Activities and floats, Crashing of activities. Project scheduling with resource constraints.	6
7	Maintenance Planning and Control: Types of Maintenance: Planned and quality Maintenance, Reliability centred maintenance, Predictive and proactive maintenance, Reliability and availability of systems, Reliability improvement.	7

Course outcomes: By the end of this course, the student will be able to:		Knowledge Level (Blooms Level)
1.	Understand and illustrate the plant layouts using Design Heuristics	L2
2.	Apply the concepts of Production management and Capacity planning in industries	L3
3.	Analyze the forecasting techniques used in industries and service sectors	L4
4.	Apply the Scheduling and sequencing techniques in job shops.	L3
5.	Analyze the various inventory models in industries.	L4
6.	Recommend the different Project management techniques applicable in projects and understand the concepts of Maintenance methods in industries.	L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	1	3	1
CO2	2	2	2	2	1	-	-	-	-	-	-	2	2	2
CO3	2	2	3	2	-	-	-	-	-	-	-	1	3	2
CO4	2	1	2	1	-	-	-	-	-	-	-	2	2	1
CO5	1	1	2	1	-	-	-	-	2	2	-	1	3	3
CO6	2	3	3	1	-	-	-	-	2	2	3	3	3	3

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Modern Production/Operation Management, Buffa and Sarin, John Wiley and Sons	2011
2	Operations Research - An Introduction, H. A. Taha, Pearson Publications	2010
3	Operations Management, P. B. Mahapatra, PHI Publication	2015
4	Operation Research, Gupta and Hira, S. Chand Publication, Delhi	2015
5	Production & Operations Management, Surya Prakash Singh, Vikas Publishing House Pvt. Ltd., Noida	2018

Course Name	:	HEAT AND MASS TRANSFER
Course Code	:	MEN5002
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To understand the fundamental principles and laws of heat transfer and explore the implications of these principles.
2	To formulate the models necessary to study, analyze and design heat transfer systems through the application of these principles.
3	To develop the problem-solving skills and practice of heat transfer in real-world applications.

Total No. of Lectures –42

Lecture wise breakup		No. of Lectures
1	CONDUCTION HEAT TRANSFER: Conduction, Convection, and Radiation Heat Transfer, Steady-State one, two and multi-Dimensional heat Conduction: Plane Wall, Insulation and R values, Radial Systems, Heat-Transfer Coefficient, Critical Thickness of Insulation, Heat-Source Systems, Thermal Contact Resistance, Conduction-Convection System Fins with uniform cross-sections, Lumped-Heat-Capacity System, Transient Heat Flow in a Semi-Infinite Solid.	10
2	PRINCIPLES OF CONVECTION: Viscous Flow, Inviscid Flow, Laminar Boundary Layer on a Flat Plate, Energy Equation of the Boundary Layer, Thermal Boundary Layer, Relation between Fluid Friction and Heat Transfer, Turbulent-Boundary-Layer Heat Transfer, Turbulent Flow in a Tube, Empirical and Practical Relations for Forced-Convection Heat Transfer. Empirical Relations for Pipe and Tube Flow, Liquid-Metal Heat Transfer.	8
3	NATURAL CONVECTION SYSTEMS: <i>Free-Convection:</i> Heat Transfer on a Vertical Flat Plate, Empirical Relations, Vertical planes and Cylinders, Horizontal Cylinders, Plates, Inclined Surfaces, Spheres.	2

4	RADIATION HEAT TRANSFER: Physical Mechanism, Radiation Properties/laws, Shape Factor and their relations, Heat exchange between non-black bodies, Infinite Parallel Planes, cylinders, spheres, Radiation shields. Solar radiation, Effect of Radiation on Temperature Measurement.	8
5	BOILING AND CONDENSATION: Boiling types, mechanism, Pool Boiling: Nucleate Boiling, CHF Flow Boiling: Plug/Slug flow, types, Mechanism Film-wise / Drop wise Condensation	4
6	HEAT EXCHANGERS: Introduction, Analysis of Heat Exchangers: LMTD for parallel flow HX, LMTD for counter Flow HX, Effectiveness for parallel Flow /Counter Flow HX, Some Important Topics from current research.	6
7	MASS TRANSFER: Velocities and mass fluxes, <i>Governing equations of mass transfer:</i> Species mass balance, Heat and mass transfer analogy, Impermeable surface model, Mass transfer driven flows, Convective mass transfer.	4

List of Experiments:		No. of Turns
1.	To determine thermal conductivity of metal rod (Al, Brass and Steel)	1
2.	To determine thermal conductivity of insulating metal.	1
3.	To determine thermal conductivity of composite wall.	1
4.	To determine thermal conductance of heat pipe & compare it with other metal rods.	1
5.	To determine heat- transfer coefficient in natural convection	1
6.	To study heat transfer from a pin-fin in natural & forced convection mode.	2
7.	To determine heat - transfer coefficient in forced convection.	1
8.	To find heat transfer coefficient for drop-wise and film-wise condensation process	1
9.	Study of CHF & pool-boiling.	1
10.	To determine effectiveness of parallel/counter flow heat exchange.	1
11.	To determine Stefan Boltzmann constant of radiation heat transfer.	2
12.	To determine the emissivity of a non-black surface.	1

Course outcomes: By the end of this course, the student will be able to:	
1	Apply basic concepts of heat transfer.
2	Develop problem-solving skills of heat transfer devices.
3	Apply scientific and engineering principles to analyze and design thermal systems.
4	Ability to understand and design the various mass transfer operations.

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Heat Transfer, R.C. Sachdeva, New Age	2012
2	Fundamentals of Heat and Mass Transfer, Incropera, Dewitt, Wiley India Edition.	1997
3	Heat Transfer, J.P. Holman, Mc Graw Hill	2014
4	Engineering Heat and Mass Transfer, M.M. Rathor, University Science Press	2015
5	Fundamentals of Heat & Mass Transfer, C. P. Kothandaraman, New Age	2012
6	A text Book of Heat & Mass Transfer by D.S. Kumar, S.K. Kataria & Sons	2016

Course Name	:	DESIGN OF MECHANICAL SYSTEMS
Course Code	:	MEN5003
Credits	:	3
L T P	:	3-0-0

Course Objectives: In this course, the student should be able to
1. Understand the mechanical systems consisting of wide range of machine elements.
2. Understand the design procedure representing empirical, semi-empirical and analytical approaches.
3. Design and analyze a real engineering system.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	GENERAL DESIGN CONSIDERATIONS: Scope and meaning of design with special reference to machine design, design processes, Concept of tearing, bearing, shearing, crushing, bending, etc. Selection of materials, Factors of safety under different loading conditions, stress-concentration factors, Design stresses for variable and repeated loads. Endurance limit and strength, Fits, tolerances and surface finish.	5
2	FASTENERS: Screws, bolts, preloaded bolts, uniform strength screws, bolts subjected to shear, tension and torque, eccentrically loaded bolted joints. Welded and riveted connection, eccentrically loaded welded and riveted connections.	5
3	SHAFTS AND AXLES: Review of torsional equation for circular shafts, Design of circular shafts subjected to axial, bending and torsional loading and its combinations under different theory of failures.	4
4	DESIGN OF FLEXIBLE MACHINE ELEMENTS: <i>Belts</i> (Flat & V), types of drives and orientations of driving & driven shaft covered by flat and V belts along with design of belts, pulleys, keys & shafts. Types of V-belts, their power ratings & design thereof, Concept and application of timing belt. <i>Chains</i> - roller chains, their designation by IS, designing w.r.t. sagging, centrifugal & transmittal loads, Complete sizing of sprockets.	6
5	BEARINGS: Types of bearings, Selection of a sliding and Rolling Bearings, <i>Design of Journal Bearing:</i> Somerfield number, bearing modulus, material for journal bearing, types of lubricants, their designated numbers. Concept of bearing body, oil & environment temperatures, Calculation of heat generation and dissipation, Design of bearing cap & bolts, <i>Design of Rolling Contact Bearings:</i> their designation w.r.t. duty, type & diameter, Concepts of catalogue, average and rating life, Bearings subjected to different loads for different time during one cycle and their equivalent dynamic load carrying capacity.	6
6	DESIGN OF CLUTCHES & BRAKES: <i>Design of Clutches:</i> Axial and Radial friction clutches, clutch load characteristics, mechanical (friction) clutches, design for uniform wear & pressure theories, Centrifugal clutches design, <i>Brakes:</i> Design of single & double block brakes, Concepts of self-locking brakes, Design of External & Internal shoe brakes, Band Brakes and Band & Block brakes.	6
7	DESIGN OF GEAR DRIVES: Factors influencing the choice of a gear, Design Details of Spur, Helical, worm and bevel gears, Nomenclature & designing of all these gears from basics of tooth loading as done by Lewis and checks for dynamic loading by Buckingham equations, beam strength, Wear load calculations and design of shafts for all these gears.	10

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic causes of failure.	L2
2	Select the suitable materials, fits, tolerances and surface finish considering manufacturing aspects.	L5

3	Analyze stresses involved with static, dynamic and fatigue loading acting on a mechanical system.	L4
4	Apply the causes of failure in designing/sizing of mechanical components.	L3, L6
5	Design a mechanical system with special focus on power transmission.	L6

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechanical Engineering Design, Shingle, J.E. Shigley & Charles R. Mischke, 6 th ed., Tata McGraw Hill.	2003
2	A Text Book of Machine Design, P.C.Sharma & D.K.Aggarwal, 12 th ed., S.K.Kataria & Sons, New Delhi	2012
3	Machine Design, Robert L Norton, Pearson.	2012
4	Fundamentals of Machine Component Design, Robert C. Juvinall & Kurt M. Marshek, 3 rd ed., John Wiley & Sons.	2000
5	Design of Machine Elements, V.B. Bhandari, 5 th edition, Tata Mc Graw Hill	2020

Course Name	:	MECHANICAL MEASUREMENT AND CONTROL
Course Code	:	MEN5004
Credits	:	3
L T P	:	3-0-0

Course Objectives: At the end of the course, the student will be able to:

1	Understand the significance of calibration, traceability and uncertainty.
2	Understand the principles of mathematical modeling within the realm of control systems.
3	Understand the measurement inaccuracies and strategies for reducing these errors.
4	Have a clear concept about the control systems across various time domains.

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
1.	INTRODUCTION: Significance of measurements, Objectives, Classification of measurements, Static and Dynamic Characteristics of Instruments, Calibration, Accuracy, precision, & repeatability, Types of errors, Effect of component errors, Tolerance analysis in manufacturing and assembly, Limits, fits and tolerances, design principles for limit gauges, Types and tolerance of limit gauges, Taylor's principle for gauges.	6
2.	MEASUREMENT OF DISPLACEMENT, STRAIN & ACCELERATION: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, Transducers for displacement, displacement measurement, potentiometer, LVDT, Accelerometer and vibrometers, practical accelerometers.	5

3.	MEASUREMENT OF FLOW, PRESSURE & TEMPERATURE: Elastic pressure transducers, piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge, Vacuum gauges, Bernoulli flowmeters, Ultrasonic Flowmeter, Thermal Mass Flow Measurement, Positive Displacement Flow meter, Electro-magnetic and Ultrasonic Flow meter.	6
4.	SURFACE ROUGHNESS MEASUREMENT, SCREW THREAD & GEAR METROLOGY: Surface Roughness Measurement Methods, Contact and Non-Contact type roughness measuring devices, 3D & Nano Level Roughness Measurement, Texture analysis, Elements of screw thread, Measurements of pitch and screw thread angle, and minor, major, effective diameters, elements of gear metrology, measurement of gear tooth thickness, gear profile, gear concentricity, pitch and run-out for involute gear.	7
5.	MEASUREMENT OF FORCE, TORQUE AND POWER: Introduction, Applications, Elastic force meters, Smart and Intelligent load cells, Torsion meters, Optical Torque Measurement, Digital and analogue tachometer, fiber optic gyroscope, Dynamometers.	5
6.	GAUGING INSTRUMENTS, FORM ERRORS AND INTERFEROMETRY: Design principles of measuring instruments, Linear and angular measurements, Vernier calipers, Micro-meters dial gauges, Bevel protectors, Sine bar, Spirit level, <i>Optical instruments:</i> autocollimators, tool room microscope length measuring machines, Various types of comparators, Straightness, Flatness, Alignment Errors, Computational techniques in measurement of form errors, Principle of light interference, Interferometers, Laser Interferometry.	8
7.	INTRODUCTION TO CONTROL SYSTEM: Introduction to control systems, Classification of control system, Open loop and closed loop systems, Mathematical modelling of control systems, Transfer Function methodology, Block diagram algebra, Introduction to PI, PD, PID controllers, Adaptive control system.	5

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recognizing and choosing the appropriate measuring instrument for a given application.	L1
2	Categorize the diverse static characteristics and identify the types of errors that manifest within the system.	L2
3	Categorize and opt for the suitable measuring device for pressure temperature, flow and strain measurement assessments.	L2
4	Examine measurement errors and distinguish between different types of control systems while also understanding various time domain specifications.	L5
5	Create a mathematical model for a system or process that can generate standard input responses.	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	2	1	2	-	-	-	-	-	-	-	2	3	3
CO2	2	2	2	1	-	-	-	-	-	-	-	2	2	3
CO3	2	2	2	1	-	-	-	-	-	-	1	2	3	3
CO4	3	2	1	1	-	-	-	-	-	-	1	1	2	2
CO5	2	3	2	2	-	-	-	-	-	-	2	2	2	2

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publications/ Reprint
1	Measurement Systems: Applications and Design, by EO Doebelin, 5th Edition, McGraw Hill.	2008
2	Instrumentation and Control System, W. Bolton, Elsevier.	2021
3	Mechanical Engineering Measurements, A K Sawhney, Dhanpat Rai & Sons, New Delhi.	2005
4	Control System Engineering by Nagrath IJ and Gopal M, Wiley Eastern, Ltd.	2018
5	Mechanical Measurements and Control, by D S Kumar, Metropolitan Book Co. Pvt. Ltd.	2015

Course Name	:	CAD/CAM
Course Code	:	MEN5005/MEO1003
Credits	:	3
L T P	:	3-0-0

Course Objectives:	
1	To provide the basic analytical fundamentals those are used to create and manipulate geometric models in a computer program.
2	To familiar the student different aspects of computer aided manufacturing.

Total No. of Lectures –42

Lecture wise breakup		No. of Lectures
1.	Fundamentals of CAD Introduction, Design Process, Application of computers in design, Creating manufacturing database, benefits of CAD, Software configuration of a graphics system, functions of a graphics package, coordinate systems.	7
2.	Geometric Transformations Mathematics preliminaries, matrix representation of 2 and 3 dimensional transformations, scaling, mirror, translation, orthographic, perspective transformations, Homogeneous transformations, Concatenation of transformation matrices.	7
3.	Geometric modeling of curves Need of Geometric Modeling, types of geometric modeling, geometric modeling representation, and geometric modeling techniques and uses, parametric representation of analytical curves line, circle, ellipse, conics and synthetic curves, Hermite curve, Bezier curve, B spline curve.	6
4.	Modelling of Surfaces and Solids Parametric representation of surfaces, plane, surface of revolution, offset surface, ruled surface, Solid modeling, CSG and Boundary Representation	6
5.	CIM Types of CIM systems, CAD-CAM link for CIMS, FMS and its types, FMS layouts, Automated material handling systems, equipment and their functions, automated guided vehicle navigation system, Automatic Storage and Retrieval Systems (AS/RS).	8
6.	Computer Aided Process Planning Introduction and benefits of CAPP, types of CAPP, Steps in variant process planning, planning for CAPP, machinability data selection systems in CAPP.	8

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Students will be able to describe the principles of Computer Aided Designing systems and the concepts of Geometric transformations and modelling.	L1
2	Students will be able to do mathematical representation of different curves, surfaces and solids.	L3, L4
3	Students will able to know about group technology & CIM Systems.	L2
4	Students will able to know about Computer Aided Process Planning.	L2, L3

CO-PO & PSO course Articulation Matrix

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO1 2	PSO 1	PSO 2
CO1	3	2	1	2	-	-	-	-	-	-	-	2	3	3
CO2	3	2	2	1	-	-	-	-	-	-	-	2	3	3
CO3	3	1	1	1	-	-	-	-	-	-	1	2	2	3
CO4	3	2	2	2	-	-	-	-	-	-	1	2	2	3

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Zimmer, E.W. and Groover, M.P., CAD/CAM – Computer Aided Designing and Manufacturing, Dorling Kingsley (2008).	2008
2.	Zeid, I. CAD/ CAM Theory and Practice. McGraw Hill. 2009	2009
3.	Bedworth, D.D., Henderson, M.R. & Wolfe, P.M. Computer Integrated Design and Manufacturing. New Delhi: Tata McGraw Hill. 1991	1991
4.	Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, prentice Hall, 2007	2007
5.	YoramKoren, Computer control of manufacturing system, 1st edition, 2005	2005
6.	Rogers, D. and Edams, Mathematical Elements For Computer Graphics, Mc Graw Hill, 2017.	2017
7.	http://nptel.ac.in/courses/112102102/ , http://nptel.ac.in/courses/112102103/	

Course Name	:	Minor Project
Course Code	:	MEP5101
Credits	:	4
L T P	:	0 0 8

Course Objectives:	
1	To enable students to identify and define a real-world engineering problem in a selected domain of mechanical engineering.
2	To develop the ability to apply fundamental engineering principles and modern tools for designing or developing solutions to the identified problem.
3	To encourage students to conduct experiments, simulations, or prototype development and analyze results for evaluating system performance.
4	To develop skills in technical documentation, teamwork, project management, and effective presentation of engineering solutions.

CO	Course Outcome
CO1	Identify and analyze a real-world engineering problem in a selected domain of mechanical engineering and formulate appropriate objectives for the project.
CO2	Apply engineering fundamentals, modern tools, and appropriate methodologies to design or develop a solution to the identified problem.
CO3	Conduct experiments, simulations, or prototype development and analyze the obtained results to evaluate the performance of the proposed solution.
CO4	Prepare a technical report and effectively present the project outcomes demonstrating teamwork, project management, and professional communication skills.

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

Course Name	:	Major Project
Course Code	:	MEP7001/8001
Credits	:	4
L T P	:	0 0 8

Course Objectives:	
1	To enable students to identify a real-world engineering problem in a selected domain of mechanical engineering.
2	To develop the ability to apply fundamental engineering principles for designing or developing solutions to the identified problem.
3	To encourage students to conduct experiments, simulations, or prototype development and analyze results for evaluating system performance.
4	To develop skills in technical documentation, teamwork, project management, and effective presentation of engineering solutions.

CO	Course Outcome
CO1	Identify and define a relevant mechanical engineering problem with clear objectives and scope.
CO2	Conduct an extensive literature review to analyze previous research and identify gaps in mechanical systems.
CO3	Develop a suitable methodology, including theoretical, numerical, or experimental approaches, for mechanical engineering applications.
CO4	Apply modern tools, simulation software, and techniques for design, analysis, and optimization of mechanical systems.
CO5	Demonstrate teamwork, project management skills, and ethical responsibilities in mechanical engineering practice.
CO6	Effectively communicate the project progress through technical reports, research papers, and oral presentations.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3											2	2
CO2	3	3				2							2	2
CO3			3	3	2	2	2						3	2
CO4			3	3	3	2						2	3	3
CO5								3	3		2	2	2	2
CO6										3			3	2

Open Elective Courses

Course Name	:	WORK STATION DESIGN AND NEURO-ERGONOMICS
Course Code	:	MEO1001/MEE1018
Credits	:	4
L T P	:	3 1 0

Course Objectives:	
1	This course is designed to teach the fundamentals of Designing of Ergonomically correct Work Stations
2	To study latest techniques used in the evaluation of human work in all contexts that leads systematically to the investigation of all the factors which affect the efficiency and economy of human energy at the work place
3	It helps in designing and improvement in the methods and procedures which are most effective, require the least efforts and are the best suited to the industrial workers.

Total No. of Lectures – 42

S. No.	Contents	No. of Lectures
1	WORK STUDY FUNDAMENTALS: Definitions, Scope and applications, Productivity and Work Study, Analysis of Work Content, Introduction to Industrial Engineering and Productivity, Measurement tools of productivity.	3
2	METHOD STUDY: Process Analysis, Process and Activity Charts, Operation Analysis, Basic Procedure, Micro Motion Study, Principles of Motion Economy.	5
3	WORK MEASUREMENT: Purposes and Uses, Basic Procedure, <i>Techniques:</i> Work Sampling, Rating and Allowances, Setting Standard Times for Jobs, Standard Data, Predetermined Motion Time Systems, MTM, Work factor and MOST, Job Evaluation of Merit Rating, Wage Incentive Plans.	8
4	ERGONOMICS AND RISK ASSESSMENT: Concepts, Issues in Work System Design, Measuring Work by Physiological Means, Work Posture, Fatigue Measurement & Evaluation, Work Systems, Limitation of Man & Machine with respect to each other by risk assessment techniques such as RULA, REBA, OCRA, NIOSH, SI, PLIBEL, QEC and OWAS.	8
5	WORK LOAD MEASUREMENT: Human Motor Activity, Anatomy of human muscles and brain lobes, Metabolism, Physical and Mental Work load and their Measurement, Introduction to work related musculoskeletal disorders and mental fatigue, Introduction to Neuro-ergonomics and quantification of neuro-signals from electro-encephalography and electromyography by linear and non-linear techniques with respect to work duration and rest periods, Introduction to Digital Human Modelling Techniques.	10
6	CLIMATES AND NOISE EVALUATION: <i>Heat Humidity:</i> Body heat Balance, Effective Temperature Scales, Zones of Discomfort, Effects of Heat on Body and Work Performance, <i>Vibration:</i> Response of Body to Low Frequency Vibration, Vibrations and Discomfort, Effect on Health of Worker, Effect of High Frequency Vibrations, Methods of Reducing Vibrations, Analysis, <i>Noise:</i> Physiological Effects of Noise, Annoyance of Noise, Speed Interference, Hearing Loss, Temporary and Permanent Threshold Shift, Effect of Noise on Performance, Reduction of Noise, Personal Noise Protection.	8

Course outcomes: By the end of this course, the student will be able to:		Knowledge Level (Blooms Level)
1	Assess all industrial activities with respect to motion study and there by design work stations.	L5 & L6

2	Quantification of physical and mental work load of the workers by latest neurological techniques.	L5
3	Identify and assess the environmental and climatic working conditions in industry.	L2 & L5
4	Analyze and apply different risk assessment techniques to predict risk involved in work with respect to development of musculoskeletal disorders.	L3 & L4
5	Application of all latest time study techniques to calculate standard time to carry-out any industrial job.	L3

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Motion and Time Study, Design and Measurement of Work, Ralph M. Barnes, Wiley India.	2009
2	Neuro-Ergonomics, Raja Parasuraman & Mathew Rizzo, Oxford University Press.	2007
3	Handbook of Digital Human Modelling, Vincent G. Duffy, CRC Press Taylor & Francis Group.	2009
4	Ergonomics Laboratory Exercises, Timothy Joseph Gallwey & Leonard William O' Sullivan, CRC Press Taylor & Francis Group.	2010
5	International Standard Manual of Ergonomics, Part-1: Lifting and Carrying; Part-2: Pushing and Pulling, Part-3: Handling of Low Loads at High Frequency.	2009
6	Neuroergonomics: Principles and Practice, Chang S. Nam, Springer	2020

Course Name	:	HYDRAULIC AND PNEUMATIC CONTROL DESIGN
Course Code	:	MEO1002/MEE1016
Credits	:	4
L T P	:	3-1-0

Course Objectives:

1	To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
2	To understand the concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
3	To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
4	To provide the exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
5	To familiarize with logic controls and trouble shooting.

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
1.	BASIC PNEUMATIC AND HYDRAULIC SYSTEMS: Introduction and basic elements of fluid power system, their structure, advantages and limitation, Applications of fluid power, pneumatic vs hydraulics control systems, Properties of fluids for hydraulic systems and governing laws, review of pneumatics in distribution of fluid power, Structure and signal flow of hydraulic and pneumatic system, Basic types and constructions of hydraulic pumps, motors and compressors, Air generation and distribution, Processing elements, Power components.	5
2.	FLUID ACCESSORIES: Air receiver, after-cooler, Air Dryer, Air Filter, Pressure Regulator, Air Lubricator, Air Service Unit, Pipeline layout, Seals, Hydraulic fluids, Hydraulic reservoir, Hydraulic filter, Hydraulic Accumulator, Intensifier, Pressure gauges and Volume Meters, Lines, Fitting and Connectors, Hydraulic seals.	5
3.	ACTUATORS AND OUTPUT DEVICES: Cylinders, Classification of cylinders on the basis of construction, Single and Double acting cylinders, their types, <i>Classification of cylinders on the basis of working Medium:</i> hydraulic and Pneumatic, rod-less cylinders, Cylinder construction, mounting arrangement Construction and working of rotary actuators such as gear, vane, piston and hydraulic motors. Theoretical torque, power, flow-rate, hydraulic motor performance, Symbolic representation of actuators (cylinders and motors), Cylinder performance characteristics, Symbols of Motors, Classification of fluid motors.	5
4.	CONTROL ELEMENTS: Classification of the valves, Direction Control valves, Poppet valves, Function of a 3/2-way NC and NO poppet valve, Manual and Mechanical operation of poppet valves, Mini poppet valves, 3/2-way and 5/2-way spool valves, Manual and mechanical operating devices for spool valves, Pneumatic operating devices for the valves , Directly operated solenoid valves , Servo solenoid valves with internal pilot and external pilot, Three-position valves, <i>Blocking valves:</i> Unidirectional, bidirectional, Signal processing valves, Nominal flow rate, Sizing of directional control distribution valves and connecting tubes, Interception valves, Non return, Flow and Pressure valves, Valve combination, Quick exhaust valve, Time delay Valve/Air Timer, Pneumatic Logic Valves, Twin Pressure valve, Shuttle Valve, Symbolic representation.	8
5.	DESIGN OF HYDRAULIC CONTROL CIRCUIT: Symbols and description of components, Rules for designing circuits, Control chain, design of circuit diagram, circuit layout, designation of individual elements, Single or semi-automatic cycle, Continuous or automatic cycle, Elementary circuits, Signals generated by limit switches, Hydraulic circuit for control of single acting and double acting cylinder, Speed control in hydraulic circuits, Bleed of circuit, Regenerative circuit, Sequencing circuit, hydraulic circuit for force multiplication, speed control of hydraulic cylinder- metering in, metering out and bleed off circuits, Pilot pressure operated circuits, Hydraulic circuit with accumulator, counter balance valve application, Memory valves, Timer, Cycle start command, Single and continuous cycle, Emergency command pressure reduction circuit, problems in circuit design.	6
6.	DESIGN OF PNEUMATIC CONTROL CIRCUIT: Pneumatic Circuits for control of single acting and double acting cylinder, <i>Simple Pneumatic Control:</i> Direct and indirect actuation pneumatic cylinders, speed control of cylinders, supply air and exhaust air throttling, Circuit with mechanical feedback, Use of flow control valve and Quick exhaust valve, Time delay circuit, Circuit with necessary conditions, Application of Twin pressure and Shuttle valve, <i>Signal Processing Elements:</i> Use of Logic gates, OR and AND gates in pneumatic application, Practical examples involving the use of logic gates, <i>Electro-Pneumatic Control:</i> Principles, signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors, Control circuitry for simple signal cylinder application.	7

7.	CONTROL SYSTEMS: Open and closed loop control system, Selection and comparison of working and control media, Control Theory, <i>Control system development</i> : Positional sketch, Displacement, step diagram, Control Chart, Function Diagram, Function chart, Circuit diagram, Cascade Design, Steps involved in cascade design, Sign Conventions, Development aspects, Emergency control.	6
-----------	--	----------

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Recall basic elements of fluid mechanics and logic gates	L1
2	Identify and analyze the functional requirements of a fluid power transmission system for a given application.	L2 & L4
3	Understand the working of hydraulic/pneumatic circuit to accomplish the desired function.	L2
4	Design an appropriate hydraulic/pneumatic/combination circuit like electro-hydraulics, electro-pneumatics for a given application.	L6
5	Select and standardize the different components of the circuit.	L5
6	Apply the control systems development techniques in industrial applications.	L3

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	2	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO6	3	3	3	3	-	-	-	-	-	-	-	1	3	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fundamentals of Fluid Power Control, John Watton, Cambridge University press.	2012
2	Hydraulics and Pneumatics, Andrew Par, Jaico Publishing House.	2005
3	Fluid Power with Applications, Anthony Esposito, Pearson.	2000
4	Introduction to Fluid Power, Thomson, Prentice Hall.	2004
5	Pneumatic systems – Principles and Maintenance, Majumdar S.R., Tata Mc-Graw Hill, New Delhi.	2005
6	Oil Hydraulics, S. R. Majumdar, Tata Mc-Graw Hill.	2017

Course Name	:	AUTOMOTIVE ENGINEERING
Course Code	:	ME01004/MEE1017
Credits	:	4
L T P	:	3-0-2

Course Objectives:

1	To develop an understanding of all the sub-components of an automotive vehicle.
2	To give knowledge about all the controlling and electronic components.
3	To gain the knowledge about new technologies being used in automotive vehicles.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: History of Automotive engineering, Classification of Automotive vehicles, Different sub-systems in automotive vehicles, History of hybrid electric, electric and fuel cell vehicles, social and environmental importance of hybrid electric, electric and fuel cell vehicles.	2
2	COOLING AND LUBRICATION SYSTEMS: Cooling systems and its components for conventional and EV, anti-freeze mixtures. Lubrication purpose and various systems of lubrication, types and desirable properties of lubricants, components like oil filters, oil pumps, and oil pressure indicators, air supply system, air filters, turbo charger and super charger.	5
3	FUEL SUPPLY SYSTEMS: Fuel injection system for petrol and diesel engines, fuel pumps (mechanical and electrical), air fuel ratio requirements, carburetors: types and general operation throttle body and multipoint fuel injection systems, electronic control module and sensing devices.	5
4	TRANSMISSION SYSTEMS: Clutch function and types, torque converters; fluid flywheel; manual and automatic transmission/ trans axles; constant mesh & synchro-mesh gearboxes, epi-cyclic gearbox, differential, propeller shafts and universal joint front and rear axles. Basic concept of electric traction and architecture, Topologies for electric drive-train and their analysis, Drive cycle implications and fuel efficiency estimations and well to wheel fuel efficiency analysis, Sizing of components for different electric drive train topologies. Matching the electric drive and ICE, Transmission selection and gear step selection, Sizing the propulsion motor, its torque, constant power speed ratio and machine dimensions,	4
5	BRAKE SYSTEMS, WHEEL & TYRES: Braking efficiency and stopping distances. Types of brakes, Drum and disc brakes. Detailed description of hydraulic and pneumatic brake. Mechanical, vacuum and electrical methods of brake actuation, servo brakes, ABS, type of wheels, tyres, type of tyres; cross ply, radial tubeless etc. specification of tyres, Supporting system for EV braking system	5
6	SUSPENSION SYSTEM: Road springs, shock absorbers, independent suspension, road springs, air suspension, hydro-elastic suspension.	4
7	STEERING SYSTEM: Steering geometry, details, correct steering angle, Ackerman steering mechanism. Cornering power, over steering and under steering. Worm wheel and Rack pinion types of steering gears. Safety steering columns, power steering, Supporting system for EV steering system.	5
8	IGNITION SYSTEM: Various ignition systems (coil and magneto) and detailed study of their components, electronic ignition system, distributor less ignition system	4
9	ENERGY STORAGE SYSTEM: Storage battery (lead acid type), Maintenance free batteries, various components, Charging system, Li-ion battery based energy storage and simplified models of battery, Fuel cells, their characteristics and simplified models, Super capacitor based energy storage, its analysis and simplified models, its advantages and challenges.	4
10	EMISSION CONTROL AND ACCESSORIES: Emission norm like EURO and BHARAT norms, methods and devices to control emissions; Automotive accessories, controlling devices such as fuel gauge, temperature gauge, indicator lights speedometer odometer, HVAC etc.	4

List of Experiments		No. of Turns
1	To study and prepare report on the constructional details, working principles and operation of the Automotive Engine Systems & Sub Systems.	2

2	To study and prepare report on the constructional details, working principles and operation of the Fuels supply systems.	1
3	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Clutches.	1
4	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Transmission systems.	2
5	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Drive Lines & Differentials.	2
6	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Suspension Systems.	1
7	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Steering Systems.	2
8	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Tyres & wheels.	1
9	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Brake systems.	1
10	To study and prepare report on the constructional details, working principles and operation of conventional Automotive Emission / Pollution control systems.	1

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Realize the need and importance of study of automobile engineering for mechanical engineers.	L4
2	Identify and compare the relative merits, demerits and applications of different systems and components in an Automobile.	L3, L4
3	Explain working of IC engines (Gasoline and Diesel) and various parameters related to it.	L5
4	Classify and illustrate various elements of Automobile like, Transmission, Brakes, Suspension, and Steering etc.	L2, L4
5	Explain recent advancements in field of Automobile engineering, like, Electric Vehicles, Hybrid Vehicles, CRDI engines, ABS etc.	L2
6	Explain and illustrate various emission and safety regulations along with their importance in automobile engineering.	L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	-	-	-	-	-	-	-	-	2	1	1
CO2	3	1	2	-	-	-	-	-	-	-	-	2	2	2
CO3	3	1	2	-	-	-	-	-	-	-	-	2	1	1
CO4	3	1	2	-	-	-	-	-	-	-	-	2	2	1
CO5	3	1	2	-	-	-	-	-	-	-	-	2	2	2
CO6	3	1	1	-	-	3	-	-	-	-	-	2	1	2

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Automobile Engg., Kirpal Singh, Standard Publication distributors, Delhi Vol. I & Vol. II	2020
2	Encyclopaedia of Automotive Engineering, D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Parts 1-6, Wiley	2015
3	Automotive Engineering Fundamentals, R. Stone and J. K. Ball, SAE International.	2004

4	The Motor Vehicle, T. K. Garrett, K. Newton, and W. Steeds, 13 th ed., SAE International.	2001
5	Internal Combustion Engines, V. Ganesan, 3rd Edition, Tata McGraw Hill.	2017
6	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, M. Ehsani, Y. Gao and A. Emadi, 2nd Edition, CRC Press.	2010
7	Car Suspension and Handling, D. B. Astow, G. Howard and J. P. Whitehead, 4th ed., SAE International.	2004
8	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley	2012

Course Name	:	CAD/CAM
Course Code	:	MEO1003/MEN5005
Credits	:	4
L T P	:	3-1-0

Course Objectives:

1	To provide the basic analytical fundamentals those are used to create and manipulate geometric models in a computer program.
2	To familiar the student different aspects of computer aided manufacturing

Total No. of Lectures –42

Lecture wise breakup		No. of Lectures
1	Fundamentals of CAD Introduction, Design Process, Application of computers in design, Creating manufacturing database, benefits of CAD, Software configuration of a graphics system, functions of a graphics package, coordinate systems, Product life cycle, sequential and concurrent engineering.	6
2	Geometric Transformations Mathematics preliminaries, matrix representation of 2 and 3 dimensional transformations, scaling, mirror, translation, orthographic, perspective transformations, Homogeneous transformations, Concatenation of transformation matrices.	6
3	Geometric modeling Need of Geometric Modeling, types of geometric modeling, geometric modeling representation, and geometric modeling techniques and uses, parametric representation of analytical curves line, circle, ellipse, conics and synthetic curves, Hermite curve, Bezier curve, B spline curve , parametric representation of surfaces, plane, surface of revolution, offset surface, ruled surface, Bezier, B spline patches, Solid modeling, CSG and Boundary Representation, CAD standards- Graphical Kernel System (GKS), Data exchange standards- IGES, STEP	8
4	Group Technology Part families, part classification and coding system, OPTIZ, MICLASS, CODE systems, Group technology machine cells, Production flow analysis.	8
5	CIM Types of CIM systems, CAD-CAM link for CIMS, types of FMS, FMS layouts, Automated material handling systems, equipment and their functions. Integration of Robots in CIMS, automated guided vehicle navigation system, Automatic Storage and Retrieval Systems (AS/RS), communication in automated manufacturing systems.	7
6	Computer Aided Process Planning Introduction and benefits of CAPP, types of CAPP, Steps in variant process planning, planning for CAPP, machinability data selection systems in CAPP.	7

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Students will be able to describe the principles of Computer Aided Designing systems and the concepts of Geometric transformations and modelling.	L1 & L2
2	Students will be able to explain the basic concepts of CNC programming and machining.	L2 & L4
3	Students will able to know about group technology, Flexible Manufacturing Systems and Computer Aided Process Planning.	L5

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Zimmer, E.W. and Groover, M.P., CAD/CAM – Computer Aided Designing and Manufacturing, Dorling Kingsley (2008).	2008
2	Zeid, I. CAD/ CAM Theory and Practice. McGraw Hill. 2009	2009
3	Bedworth, D.D., Henderson, M.R. & Wolfe, P.M. Computer Integrated Design and Manufacturing. New Delhi: Tata McGraw Hill. 1991	1991
4	W. M. Neumann and R.F. Sproul, Principles of Computer Graphics, McGraw Hill, 1989.	1989
5	Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, prentice Hall, 2007	2007
6	YoramKoren, Computer control of manufacturing system, 1st edition, 2005	2005
7	Rogers, D. and Edams, Mathematical Elements For Computer Graphics, Mc Graw Hill, 2017.	2017
8	http://nptel.ac.in/courses/112102102/ , http://nptel.ac.in/courses/112102103/	

Departmental Elective Courses-I

Course Name	:	OPTIMIZATION TECHNIQUES IN ENGINEERING
Course Code	:	MEE1001
Credits	:	4
L T P	:	3-1-0

Course Objectives: In this course, the student will be able to	
1	Understand engineering minima/maxima problems into optimization framework.
2	Learn computational procedures to solve optimization problems.
3	Learn software tool(s) to implement important optimization methods.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Introduction to Optimization, Adequate and Optimum Design, Principles of Optimization, Statement of an Optimization Problem, Classification, Formulation of Objective Function, Design Constraints.	4
2	ONE-DIMENSIONAL UNCONSTRAINED OPTIMIZATION METHODS: Optimality Criteria - necessary and sufficient conditions, Bracketing methods, Region-elimination methods, Point estimation method, Gradient based methods, Sensitivity analysis. Introduction to MATLAB tool and its application to these methods.	8
3	MULTI-DIMENSIONAL UNCONSTRAINED OPTIMIZATION METHODS: Optimality Criteria, Unidirectional search, Direct search methods, Gradient-based methods. Conjugate-direction methods, Quasi-Newton methods. MATLAB application.	8
4	CONSTRAINED OPTIMIZATION METHODS: Constrained Optimization Criteria, Penalty Methods, Method of Multipliers, Direct search methods, Linearization methods, Feasible Direction method, Generalized Reduced Gradient Method.	6
5	NON-TRADITIONAL OPTIMIZATION TECHNIQUES: Traditional vs non-traditional optimization, need for nontraditional optimization techniques, evolution of non-traditional optimization techniques in engineering.	4
6	GENETIC AND ANN TECHNIQUES: Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, Fuzzy logics, Artificial Neural Network (ANN) based Optimization. MATLAB application.	12

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the fundamentals of Linear and Dynamic Programming problems.	L2
2	Apply classical optimization techniques and numerical methods of optimization to solve problems.	L3
3	Analyze and make inferences of different evolutionary algorithms.	L4
4	Explain and identify the importance of Integer programming technique and apply different techniques to solve engineering problems	L5
5	Adapt software as a tool(s) to implement optimization algorithms.	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	2	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	3	-	-	-	-	-	-	-	1	2	1
CO3	2	1	2	1	-	-	-	-	-	-	-	1	2	1

CO4	2	3	2	3	2	-	-	-	-	-	-	2	3	1
CO5	2	1	2	3	2	-	-	-	-	-	-	1	2	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, PHI, New Delhi.	2012
2	Genetic Algorithms in Search, Optimization and Machine Learning, Goldberg, D.E., Addison-Wesley.	1989
3	Multi-objective Optimization using Evolutionary Algorithms, Deb, K., John Wiley and Sons.	2009
4	Engineering Optimization Theory and Practice, S. S. Rao, John Wiley and Sons.	2019
5	Modern Heuristic Optimization Techniques: Theory and Applications, Kwang Y. Lee, Mohamed A. El-Sharkawi, Kluwer.	2008

Course Name	:	COMPUTER INTEGRATED DESIGN AND MANUFACTURING
Course Code	:	MEE1002
Credits	:	4
L T P	:	3-1-0

Course Objectives: To impart the knowledge of

1	Various phases of design and manufacturing of products considering different aspects of manufacturability, ease of assembly and environment issues.
2	Computer integrated environment in Industries.
3	Smart factories with a concept of Industry 4.0.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	PRODUCT DESIGN: Introduction, Essential factors of product design, Phases and approaches of design, Robust product design, parameter and tolerance design, Aesthetic and ergonomics in product design.	8
2	COMPUTER INTEGRATED ENVIRONMENT: Integrating CAD/CAM/CAE tools, objectives, product development cycle integrated with CAD/CAM tools, Concept development and modelling, Introduction to finite element analysis and rapid prototyping, product data management, Computer aided process planning, Flexible manufacturing system, Concept of group technology, Rapid tooling.	8
3	NUMERICAL CONTROL IN MACHINING PROCESSES: Introduction to NC, CNC and DNC Machines, Components of CNC machines, Control systems in CNC, CNC tooling and fixtures, <i>CNC part programming:</i> G-Codes and M-Codes, Canned cycles, Manual part programming, Computer aided part programming.	8
4	DESIGN FOR MANUFACTURING AND ENVIRONMENT: Design for manufacturing (DFM), Design for assembly (DFA), guidelines and principles of DFM and DFA, General design principles for manufacturability, Strength and mechanical factors, Material selection, Process capability, Feature tolerances, Geometric tolerances, Assembly processes, <i>Design for environment:</i> Introduction, objectives and issues, guidelines, Lifecycle assessment, Basic method, Design to minimize material usage, Design for recyclability, Design for Energy efficiency, Design for sustainability	8

5	INDUSTRY 4.0: Introduction, Chronological development of Industry 4.0, Today's factory, Globalization, Basic principles and technologies of a Smart Factory, Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Cloud Computing and Manufacturing, Security issues within Industry 4.0 networks, Human-Robot Collaboration in Industry.	10
----------	--	-----------

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understand about the essential factors and phases of product design.	L2
2	Apply the CAD/CAM tools in manufacturing, service and environmental aspects.	L3
3	Apply the CNC and DNC machining processes in manufacturing.	L3
4	Design for manufacturability and recyclability of product.	L6
5	Estimate the energy efficiency in manufacturing.	L5
6	Analyze and adapt of industry 4.0 in manufacturing.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	1	-	-	-	-	-	1	1	3	1
CO3	3	3	3	2	2	-	-	-	-	-	2	2	3	2
CO4	3	3	3	3	1	-	2	-	-	-	1	2	3	2
CO5	3	2	3	2	1	-	-	-	-	-	-	1	3	2
CO6	2	2	2	1	1	-	-	-	-	-	-	1	2	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Product Design and Development, Karl T. Ulrich and Steven D. Eppinger, McGraw Hill	1999
2	CAD/CAM Principles and Applications, P N Rao, Tata McGraw-Hill.	2010
3	CAD/CAM, H P Groover and E W Zimmers, Prentice Hall.	1984
4	Engineering Design and Design for Manufacture and Structural Approach, Dickson, John. R and Corroda Poly, Field Stone Publisher, USA.	1995
5	Computer Aided Design and Manufacturing, Sadhu Singh, Khanna Publishers	1998
6	Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress, Springer Nature	2017
7	The Fourth Industrial Revolution, Klaus Schwab, Penguin Random House	2017

Course Name	:	MECHANISMS AND MACHINES
Course Code	:	MEE1003
Credits	:	4
L T P	:	3 -1- 0

Course Objectives: In this course, the student will be able to understand the

1. Concepts of various basic Mechanisms and Machines.
2. Kinematic analysis and synthesis of mechanisms.
3. Design process based on different mechanisms for a given application.
4. Mechanisms to be used for various machines and do failure analysis.

Total No. of Lectures – 42

Sr. No.	Lecture wise breakup	No. of Lectures
1	INTRODUCTION: Mechanisms, classifications, relative and absolute motion, four bar mechanisms, planar and spatial mechanisms, inversion and equivalent linkage, transmission deviation and pressure angles, kinematic analysis of planar motion, relative velocity and velocity difference, pole and centrodes, relative acceleration and acceleration difference.	6
2	KINEMATIC SYNTHESIS OF MECHANISMS: Movability, Number synthesis, Frudenstein's equation, Chebyshev spacing of precision points, Stages of kinematic synthesis and errors, Two and three position synthesis of Four-bar mechanism & slider crank mechanism, Overlay method, Bloch's method, Transmission angle in four bar and slider crank mechanism, function and path generation, Limit position & Least square techniques.	10
3	LOWER PAIRS: Universal joint- single and double, calculation of maximum torque, Oldham's Coupling, steering mechanism including Ackermann's and Davis steering mechanism, concepts of power steering, Mechanism with lower pairs, pantograph, exact and approximate straight-line motion, engine indicator, elliptical trammel.	6
4	BELTS, ROPES AND CHAINS: Materials, type of drive, idle pulley, intermediate or counter shaft pulley, angle and right-angle drive, quarter turn drive, velocity ratio, crowning of pulleys, loose and fast pulleys, stepped or cone pulleys, ratio of tensions on tight and slake sides of belts. Power transmitted by belts including consideration of creep and slip, centrifugal tension and its effect on power transmitted. Use of gravity, idler, flat, V-belts and rope, materials, Length of belt, rope and chain drive, types of chains.	6
5	FORCE ANALYSIS: Couple, equilibrium of forces and force systems, Free body diagrams, D-Alembert principle, Forces on slider crank mechanism, quick return mechanism & four-bar mechanism with more than two forces acting on a link, slider crank mechanism, Forces and couples for link and reciprocating parts; Dynamically equivalent system. analytical and graphical methods of solutions; Torque, inertia and gravitational force of a four bar linkage.	6
6	BRAKES AND DYNAMOMETERS: Types of brakes, principles of friction brakes, band, band & block and internal expanding shoe brakes, differential band brake, description of vacuum brake, types of dynamometers, measurement of power by prone brake and rope brake dynamometers, Heenan and Froude's Hydraulic dynamometer, Bevis-Gibson's flash light torsion dynamometer, belt transmission dynamometer.	8

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basic concepts of Kinematics and Dynamics	L1
2	Understand and apply concepts of kinematics and dynamics on the mechanism & machines.	L2, L3
3	Analysis and synthesis of mechanisms using different techniques.	L4, L6
4	Understand and evaluate various power transmission elements for their kinematic domain.	L2, L5
5	Dynamic analysis of various power transmission elements and mechanisms.	L4

CO-PO & PSO Course Articulation Matrix

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

CO4	3	3	3	2	-	-	-	-	-	-	-	2	3	1
CO5	3	3	3	2	-	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Theory of Machines, V.P. Singh, Dhanpat Rai & Co. Pvt. Ltd.,	2014
2	Theory of Machines, P.L. Ballaney, Khanna publishers.	1994
3	Theory of Machines, Shigley, Tata McGraw Hill.	1981
4	Mechanism & Machine Theory, J.S. Rao & R.V. Dukhipati, Wiley Eastren Ltd.	1992
5	Theory of Mechanisms, Amitabh Gosh & A.K. Mallik, East West Press Machines Private Ltd.	2008
6	Theory of Machines, S S. Rattan, McGraw Hill Education (India)	2019

Course Name	:	VIBRATION AND NOISE CONTROL
Course Code	:	MEE1004
Credits	:	4
L T P	:	3-1-0

Course Objectives: In this course, the student should be able to understand	
1	Theoretical and practical aspects of noise and vibration.
2	About the sources of vibration and noise in mechanical systems.
3	About the measurement techniques and instruments used in industry.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Review of vibration theory, one degree, two degrees, and multi-degrees of freedom vibration systems.	3
2	VIBRATIONS UNDER GENERAL FORCING CONDITIONS: Response under periodic force of regular and non-regular form, non-periodic force using Convolution Integral and Laplace transform.	7
3	MEASUREMENT AND ANALYSIS OF VIBRATIONS: Vibration measuring and analyzing instruments. Various types of transducers, data acquisition system, vibration analysis techniques.	6
4	VIBRATION CONTROL: Reduction of Vibration at the Source, Vibration Isolation, Vibration absorbers, active and semi-active vibration control systems.	7
5	FUNDAMENTALS OF NOISE: One dimensional wave equation, Sound propagation in 3-D space, important acoustic quantities and their relations, additive effects of sound.	6
6	MEASUREMENT OF SOUND: Various types of transducers, measurement of sound pressure, sound intensity and sound power.	6
7	NOISE CONTROL: Principles of passive noise control, sound absorption, noise barriers, and active noise control.	7

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Review the fundamentals of vibrations and sound.	L1
2	Evaluate the vibration under general forcing condition.	L5
3	Measure, analyze and control vibrations in a machine.	L2, L4

4	Design and develop vibration and noise control systems.	L6
5	Apply the vibration and noise standards on engineering systems.	L3

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechanical Vibrations, S. S. Rao, Pearson Education Inc.	2017
2	Mechanical Vibrations, V. P. Singh, Dhanpat Rai & Sons, Delhi	2014
3	Fundamental of Vibrations, Leonard Meirovitch, Mc-Graw Hill Inc.	2001
4	Noise control in industry: a practical guide, Cheremisinoff, Nicholas, Noyes Publications, New Jersey.	2003
5	Fundamentals of noise and vibrations analysis for engineers, Norton, M.P and Karczub, D.G, Cambridge University press, New York.	2003
6	Fundamentals of noise and vibration, Fahy, Frank and Walker, John, Taylor and Francis, London.	1998
7	Mechanical Vibrations, 6 th edition by Singiresu S. Rao, Pearson Education, India	2018

Course Name	:	PRODUCTION ENGINEERING
Course Code	:	MEE1005
Credits	:	4
L T P	:	3 1 0

Course Objectives:

1	To imparts the specialized knowledge of CNC machines and CNC programming for machining processes.
2	To impart the knowledge on design and fabrication of various types of Jigs, Fixtures, Dies and Tooling used in manufacturing of various products.
3	To impart the knowledge of geometrical tolerances, surface finishes and fits system used in mechanical assembly.
4	To impart the knowledge of process planning and process optimization, optimal machining speed and maximum production rate with optimal cost.

Total No. of Lectures –42

Lecture wise breakup		No. of Lectures
1	NC AND CNC MACHINES: Introduction, Components, Control systems, CNC tooling and fixtures, CNC part programming: basic G-Codes and M-Codes, Canned cycles, Manual part programming, Computer aided part programming (APT), Canned cycles	7
2	JIGS & FIXTURE DESIGN: Principles, design of jigs and fixtures, degrees of freedom, principle of locating and clamping, hydraulic and pneumatic locating and clamping devices, jigs for drilling, drill bushes; Fixtures: milling, lathe, drilling, grinding, broaching, boring and Assembly fixtures.	8

3	TOOL AND DIE DESIGN: Press tool operations: Shearing, blanking, piercing, trimming, shaving, notching, nibbling, coining, bending, drawing, embossing, stretch forming; Press working equipment's, Dies: Types, components of cutting die; methods of reducing cutting forces; Die design: blanking die, piercing die, drawing die and bending die, forging dies, design of die blocks, punches and strippers; Strip layout, Mathematical analysis of tool and die design.	8
4	MANUFACTURING OF TOOLS AND DIES: Manufacturing of Single, double and multi-point cutting tools, Carbide tool inserts, brazed tools, coated tools, Manufacturing of Dies, die materials, electro-removal processes, cast dies, Resinking of dies, sizes of die blocks, various conventional and non-conventional methods for die manufacturing, heat treatment of cutting tools and dies, Numerical analysis. MT	7
5	METROLOGY & INSPECTION: Limits, fits and tolerances, standard and limit gauges, design of gauges, elements of surface roughness, evaluation of surface roughness, representation of surface roughness, Measurement of surface roughness, surface finishing process, steps of inspection, introduction to coordinate measuring machine and automated inspection technique, elements and relationship of surface finish related to production methods and measurement; measuring devices used in inspection and quality control.	6
6	OPTIMIZATION OF MACHINING CONDITION: Optimization of cutting speed for minimum cost and maximum production, machining parameters optimization, Machine Tool replacement, method of distributing depreciation, Introduction to reverse engineering and applications, mathematical techniques for optimization, single variable and multi-variable optimization techniques.	6

Course outcomes: By the end of this course, the student will be able to:		Knowledge Level (Blooms Level)
1	Understand the hardware of CNC machines, supportive tooling system such as Jigs and Fixtures for smooth manufacturing activities.	L2
2	Understand the fact and idea of various types of press working tools/ dies, their manufacturing processes and quality inspection devices.	L2
3	Interpret different types of geometric fits and selection of suitable manufacturing process for required geometrical tolerances.	L5
4	Design different types of tools and dies	L6
5	Apply G-codes and M-codes for creating CNC part programming for various machining operations.	L3

CO-PO & PSO course Articulation Matrix

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

Name of Book/ Authors/ Publisher		Year of Publication/ Reprint
1	Tool Design, Donaldson, TMH Publication	2010
2	Fundamentals of tool Design, ASTME	2010
3	Production Engineering, P.C. Sharma, S Chand Publications.	2014
4	Jig and Fixture Design, Edward G Hoffman, Cengage learning	2004
5	Manufacturing Technology (Machining), P.N. Rao, 2 nd ed., Tata McGraw Hill.	2017

Course Name	:	CONVECTIVE HEAT AND MASS TRANSFER
Course Code	:	MEE1006
Credits	:	4
L T P	:	3-1-0
Course Objectives:		
1	To understand basic principles of free and forced convection heat transfer processes.	
2	To be able to formulate and solve convective heat transfer problems.	
3	To be able to evaluate energy requirements for operating a flow system.	
4	To understand the mass transfer processes.	

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Basics of thermodynamics, Fluid mechanics and heat transfer, Continuity, momentum and energy equations, Reynolds transport theorem, Rules of scale analysis, Concept of heat line visualization.	4
2	LAMINAR FORCED CONVECTION - EXTERNAL FLOWS: Boundary layer concept, velocity and thermal boundary layer, Governing equations, Similarity solutions, Various wall heating conditions, Flow over sphere, wedge and stagnation flow.	9
3	LAMINAR FORCED CONVECTION - INTERNAL FLOWS: <i>Fully developed laminar flow:</i> Constant heat flux, Constant wall temperature, Mean temperature, Fully developed temperature and velocity profile, Thermally developing flow and thermal-hydraulic developing flow.	5
4	EXTERNAL NATURAL CONVECTION: Governing equations for natural convection, Boussinesq approximation, Dimensional analysis, Boundary layer equations, Scale analysis, Low and high Prandtl number fluids, Combined natural and forced convection.	7
5	INTERNAL NATURAL CONVECTION: Scaling analysis, Natural convection in enclosures: Isothermal and constant heat flux, Side-walls and triangular enclosures, Heated from below, Inclined enclosures, Annular space between horizontal cylinders.	6
6	TURBULENT BOUNDARY LAYER FLOW: Transition to turbulent flow, Turbulent flow and its characteristics, Boundary layer equations, Mixing length model, Flow over a single cylinder, Cross-flow over array of cylinders, Natural convection along vertical walls, Turbulent duct flow and Free turbulent flows.	6
7	MASS TRANSFER: Introduction to mass transfer, Concentrations, velocities and mass fluxes, <i>Governing equations of mass transfer:</i> Species mass balance, constitutive equations, Boundary conditions, Heat and mass transfer analogy, Impermeable surface model, Mass transfer driven flows and Simultaneous heat and mass transfer.	5

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Revisit the basics of thermodynamics, heat transfer and fluid mechanics.	L2
2	Apply the concepts of convective heat transfer to solve the problems of theoretical and practical interest.	L3
3	Analyze thermo-hydrodynamics of internal and external, laminar and turbulent, and natural and forced convection flows.	L4
4	Optimize, evaluate, and design the convective heat transport based thermal systems.	L5 & L6
5	Analysis and application of mass transport principles to cooling tower, condensers, and humidifier/dehumidifier.	L4

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Convection Heat Transfer, A. Bejan, John Willey and Sons, New York.	2001
2	Convective Heat Transfer, Louis, C. Burmeister, John Willey and Sons, New York.	2003
3	Convective Heat and Mass Transfer, Kays and Crawford, 4 th Ed., McGraw Hill.	2017
4	Convective Heat and Mass Transfer, S. Mostafa Ghiaasiaan, South Asian Edition, Cambridge India	2014
5	Fundamentals of Convective Heat Transfer, Gautam Biswas, Amaresh Dalal, Vijay K. Dhir, 1 st ed., CRC Press.	2019

Course Name	:	INTERNAL COMBUSTION ENGINES
Course Code	:	MEE1007
Credits	:	4
L T P	:	3-1-0

Course Objectives: Students will learn about

1	The basic cycles of operation of internal combustion engines.
2	Basic configuration of I.C. engines and its different parts.
3	Different sub-systems of IC engines.
4	The design/operating characteristics of different types of internal combustion engines which affect its performance.
5	Recent developments in the field of IC engine fuels and other non-conventional engines.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Heat Engines, Internal and external combustion engines, classification of I.C. Engines, Cycles of operation in 4 stroke /2stroke /SI/CI engines, Valve timings diagram, low speed and high-speed engines, Rotary /Wankel Engines, Applications, Performance parameters.	4
2	WORKING CYCLES: <i>Air standard cycles:</i> assumptions, Otto, Diesel and Dual cycles, efficiency, M.E.P. & their comparison. <i>Fuel Air Cycles:</i> effect of dissociation and operating variables, comparison of air standard and fuel-air cycles. <i>Actual Cycles,</i> losses, comparison with air standard cycles.	4
3	IC ENGINES' SYSTEMS: <i>Carburetion System:</i> definition, Air-Fuel ratio, simple carburetor, essential parts of carburetor, compensating devices. <i>Fuel Injection Systems:</i> classification, parts of mechanical fuel injection systems and brief study of electronic injection systems. <i>Ignition Systems:</i> energy requirement, Battery/Magneto/ Modern ignition systems, i.e., TCI and CDI systems, Ignition timing and firing order, Spark advance mechanism. <i>Cooling and Lubrication Systems:</i> wet, mist and dry sump lubrication systems, Factors affecting mechanical friction, Lube properties SAE rating, necessity of cooling, parameters affecting engine heat transfer, air and water cooling, Radiators	9

4	COMBUSTION IN I.C. ENGINES: Homogeneous/Heterogeneous mixtures, stages of combustion in S.I. Engines, velocity of flame propagation; detonation, effects of engine variables on detonation; theories of detonation, pre-ignition, S.I. engine combustion chambers. Stages of combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, C.I. engine combustion chambers.	8
5	ENGINE EMISSION AND CONTROL: Pollution due to IC Engines, Exhaust Emissions -Hydrocarbons, Carbon Monoxide, Oxides of Nitrogen (NO _x), Other Emissions. Controls: Thermal Converters, Catalytic Converters, Particulate Traps, Chemical Methods, Exhaust Gas Recirculation (EGR), Evaporation Control Device, Crankcase Blow-by.	4
6	ENGINE TESTING AND PERFORMANCE: Measurement of Power, Fuel/ Air Consumption, Speed etc. Performance Parameters: BHP, IHP, FHP, Mechanical, Indicated and Brake Thermal Efficiency, Mean Effective Pressure, Charging Efficiency, Volumetric Efficiency, bsfc, isfc, Heat Balance Sheet, Performance Curves	5
7	SPECIAL TOPICS: Supercharging, Variable Compression Ratio (VCR) Engine, Two stroke engines, Common Rail Direct Injection (CRDI) Engines, Dual fuel /multi-fuel engines, Homogeneous charge compression ignition (HCCI) engine, Wankel Engine, Stratified Charge engines, Alternate fuels for IC engines, Hybrid Electric Propulsive System, Comparison of automatic propulsion system.	8

S. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Bloom Level)
1.	Identify and rationally choose the appropriate type of I.C. Engine(s) for a particular application.	L2
2.	Apply the basic concepts to select the different subsystems of an IC engine.	L3
3.	Analyze the performance of engines at different operating parameters.	L4
4.	Analyze and justify the suitability of conventional and non-conventional fuel for existing and futuristic IC engines.	L4
5.	Select and modify the combustion system integrals to minimize pollution	L5 & L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Internal Combustion Engines, V Ganeshan, 4 th ed., Mc Graw Hill	2017
2	Internal Combustion Engines, M.L. Mathur and R.P. Sharma, Dhanpat Rai Publication	2010
3	Engineering Fundamentals of Internal Combustion Engines, Willard W. Pulkrabek, Pearson	2007
4	Internal Combustion Engines Fundamentals, John B. Heywood, Mcgraw Hill Science	2017
5	Internal Combustion Engines Applied Thermo-sciences, Colin R. Ferguson, Allan T. Kirkpatrick, 3 rd ed., Wiley, Student Edition	2015

Course Name	:	POWER PLANT ENGINEERING
Course Code	:	MEE1027
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To understand different types of steam cycles and estimate efficiencies in a steam power plant.
2	To describe basic working principles of hydro, gas turbine, diesel engine and nuclear power plants.
3	To understand the power plant economics, depreciation and cost of producing power.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	STEAM POWER PLANT: Introduction, configuration of steam power plant, basic cycles of operation, Reheat-regenerative cycle, binary cycle, topping and superimposed cycle. Steam generators: Modern generators, once through and fluidized bed boilers design. Consideration of modern steam generators, furnace, fuel firing methods, fuel and ash handling systems, various accessories of steam generators, steam pressure & temperature control. Steam Turbines: Details of construction, accessories, governing, turbine blades, power calculations, arrangement of turbines, industrial turbines. Condensers and Cooling Towers: Performance, heat transfer design, calculations, efficiencies, detail construction, cooling water circuit, environmental aspects.	12
2	HYDEL POWER PLANT: Hydrology, rainfall measurement hydrographs, flow duration curves, site selection, classification of hydro stations, capacity of hydro stations, selection of prime movers, governing of water turbines, operation of different components of hydro station reservoirs, dam, spillway, canals, penstock, water hammer surge tank, Draft-tubes, specific speeds of turbines, Advantages and disadvantages of HPP.	6
3	DIESEL POWER PLANT: Diesel plant elements, arrangements of diesel plant, diesel engine fuel injection system, air intake system, engine lubrication and engine cooling systems, supercharging and superchargers. Methods of starting and stopping the engines. Advantages and disadvantages of using diesel power plant, Economics of diesel plant over steam and hydro-electric plant.	6
4	GAS TURBINE POWER PLANT: General features and characteristics and their application power plants, Analysis of different cycles, components of gas turbine power plants, governing system of gas turbine plant, advantages of G. T. plant, Gas and steam turbines, combined cycles –Thermodynamic analysis for optimum design, advantages and performance of combined cycles, economics of combined cycle.	8
5	NUCLEAR POWER PLANT: Atomic structure, energy levels, binding energy. Radioactivity, decay laws, half-life, nuclear reaction. The fission chain reaction (Controlled and uncontrolled). Maintenance of chain reaction, heat removal, reactor fuels and materials. Some common types of power reactors. Pressurized water reactor, boiling water reactor and gas cooled reactor. Reactor system safety provisions, Fusion reaction, site selection, Economics of nuclear power plants, Air pollution, Power plant and the air pollution, Units of radiation dose, Control of internal and external hazards, Combined cycle with nuclear power plants.	7
6	POWER PLANT ECONOMICS: Fluctuating load on power plants, load curves, various performance factors of power station. Effect of variable load power plant design and operation. Economic analysis of power plants, tariffs, load division, combined operation of different power plants, heat rate, incremental heat rate, selection of power plant and station equipment.	3

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand, identify and interpret constructional features and working of various components of Steam power plant.	L1, L2, L3, L4
2	Classify various types of fuels used in thermal power plant and explain their handling, combustion etc. Explain ash handling and dust collection mechanism, principle of fluidized bed combustion	L1, L2, L3, L4
3	Understand, identify and interpret constructional features and working of various components of Hydel power plant.	L1, L2, L3, L4
4	Understand, identify and interpret constructional features and working of various components of Diesel and gas power plant.	L1, L2, L3, L4
5	Understand, identify and interpret constructional features and working of various components of nuclear power plant.	L1, L2, L3, L4
6	Evaluate the Effect of variable load power plant design and operation and its economic analysis.	L1, L2, L3, L4, L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO2	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO4	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO5	3	3	2	-	-	-	-	-	-	-	-	2	3	1
CO6	3	3	2	-	-	-	-	-	-	-	-	2	3	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Power Plant Engineering, T. Morse, Tata McGraw Hill.	2010
2	Power Station Engineering & Economy, Skrotzki, McGraw Hill.	2008
3	Steam Power Plants, Potter, Ronald Press co., New York	2011
4	Nuclear Power Plant, Taylor, Philosophical Library.	2010
5	Power Plant Engineering, Mahesh Verma, Metropolitan.	2012
6	Power Plant Engineering, Domkundwar, Dhanpat Rai and sons	2016

Departmental Elective Courses-II

Course Name	:	TOTAL QUALITY MANAGEMENT
Course Code	:	MEE1008
Credits	:	4
L T P	:	3-1-0

Course Objectives: To imparts the knowledge of	
1	Basic concepts in Quality, Quality planning & Control and Process capabilities.
2	Statistical Process Control and use of Quality Control charts in manufacturing and service sectors.
3	Total Quality Management concepts and Quality Standard (ISO) systems.
4	Reliability and Six Sigma and applications in industries.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Introduction to quality (Services and manufacturing), Quality planning and control, Quality cost, Economics of quality control, Phases of quality evolution	4
2	PROCESS CAPABILITY & MEASUREMENTS: Specification, tolerances and process capability studies, precision reproducibility and accuracy of method measurement, Taguchi method.	4
3	STATISTICAL QUALITY CONTROL: Inspection and quality control, statistical quality control, statistical process control, sampling plans and control charts for variables and attributes, economics of sampling charts.	8
4	QUALITY CONCEPTS: Quality Assurance, Total Quality Control, Total quality concept, Deming's 14 points.	4
5	TOTAL QUALITY MANAGEMENT: Concept, quality planning and improvement, quality team and circles, just in time (JIT).	6
6	QUALITY STANDARDS: Definition, applications, implementation procedure and requirements of Quality, ISO 9001, ISO 9002, ISO 9003, ISO 9004, ISO 14000, ISO 27000, ISO 31000, Quality standards.	6
7	QUALITY & RELIABILITY: Product quality and reliability, failure data analysis and life testing, redundancy in design.	6
8	SIX SIGMA: Concept, definition, procedure and applications, TQM and six sigma, Indian industries, certification, process capabilities and case studies.	4

Sr. No.	Course outcomes: By the end of this course, the students will be able to:	Knowledge Level (Blooms Level)
1	Understand the concepts of concepts of Quality & Quality standards in industries.	L2
2	Remember the capabilities of various processes in industries and service sectors.	L1
3	Apply the concepts of sampling plans and control charts for process improvement in various organizations.	L3
4	Apply the concepts of TQM, Quality Assurance and JIT in industries.	L3
5	Analyze the ISO Quality standards; used in various organizations.	L4
6	Estimate the reliability of various systems and Apply the Six Sigma concepts in industries and service sectors.	L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	1	2	1	-	-	-	2	-	1	2
CO2	2	1	2	1	2	-	2	-	-	-	1	-	1	1
CO3	3	2	1	-	2	-	2	-	1	-	1	-	1	2
CO4	3	1	1	2	1	2	2	-	1	-	2	-	1	2
CO5	1	2	1	1	2	1	2	-	1	1	-	-	1	2
CO6	2	2	2	-	2	1	1	-	-	2	2	-	1	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Statistical Quality Control, E. L. Grant, 6 th ed., McGraw-Hill	2017
2	Statistical Quality Control, M. Mahajan, Dhanpat Rai & Co. (P) Limited	2016
3	Statistical Quality Control, J. M. Juran, 5 th ed., McGraw-Hill	1990
4	Quality Control, Hansen & Ghare, PHI	2005
5	Statistical Quality Control, R.C. Gupta, 9 th ed., Khanna Publishers	2016

Course Name	:	FRACTURE MECHANICS AND FATIGUE
Course Code	:	MEE1009
Credits	:	4
L T P	:	3-1-0

Course Objectives: In this course student will be able to understand

1. The physical and mathematical principles of fracture mechanics and fatigue.
2. Crack problem formulation through stress, displacement and energy methods.
3. The design principles of materials & structures using various fracture mechanics approaches with lower factor of safety.
4. The modern theory of fatigue dealing with nucleation and rate of propagation of crack.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	BACKGROUND: Introduction, kinds of failure & history, brittle and ductile fracture, modes of fracture failure, different techniques of fracture mechanics, potency of a crack, damage tolerance.	3
2	ENERGY RELEASE RATE (ERR): Introduction, Griffith's work and his dilemma, Surface energy, Griffith's realization and analysis, Mathematical formulation of ERR, ERR of Double Cantilever Beam specimen, anelastic deformation at crack tip, crack resistance, stable and unstable crack growth, R- curve for brittle crack, Thin plate v/s thick plate, critical ERR.	6
3	STRESS INTENSITY FACTOR (SIF): Introduction, Linear Elastic Fracture Mechanics, stress and displacement fields in isotropic elastic material, SIF and its mathematical background, Approach of Westergaard for different mode of fracture and its analysis.	9
4	SIF OF MORE COMPLEX CASES: Other applications of Westergaard approach, application of the principles of superposition, crack in a plate of finite dimensions, Edge and embedded cracks, Relationship between ERR and SIF, critical SIF, bending and twisting of cracked plates.	5
5	ANELASTIC DEFORMATION AT THE CRACK TIP: Investigation at the crack tip, approximate shape and size of the plastic zone, effective crack length,	4

	effect of plate thickness.	
6	ELASTIC PLASTIC ANALYSIS THROUGH J-INTEGRAL: Relevance and scope, definition of J-integral, path independence, stress-strain relation, discussion on J-integral, Engineering Approach of J-integral.	4
7	CRACK TIP OPENING DISPLACEMENT (CTOD): Introduction, relationship between CTOD, SIF and ERR for small scale yielding, Equivalence between CTOD and J integral,	4
8	TEST METHODS: K_{IC} test techniques, Test methods to determine J_{IC} , Test methods to determine G_{IC} and G_{IIC} , Determination of critical CTOD.	2
9	FATIGUE FAILURE: Introduction, Terminology, S-N curve, crack initiation, crack propagation, Effect of an overload, crack closure, variable amplitude fatigue load.	3
10	CRACK DETECTION THROUGH NDT: Visual, LPI, Magnetic Methods, Radiography, Ultrasonic	2

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall various kind of failures, ductile and brittle fracture of metals.	L1
2	Understand various modes of fracture and analyze the behavior of engineering materials having microscopic flaws by various approach	L2, L4
3	Apply the concepts of fracture mechanics philosophy to design of structural components taking into account presence of flaws, nature of loading and constitutive behavior of the material.	L3, L6
4	Apply the concept of fatigue failure of structure under variable fluctuation loading to engineering problems	L3
5	Understand the various test procedures to determine the fracture mechanics parameters of the materials.	L2, L5

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Elements of Fracture Mechanics, Prashant Kumar, 1 st ed., TMH, New Delhi.	2017
2	Elementary Engineering Fracture Mechanics, David Broek, Kluwer Academic Publishers Group, Dordrecht, Netherlands.	1986
3	Fracture Mechanics - Fundamentals and Applications, T. L. Anderson, 3 rd ed., CRC Press, Taylor and Francis Group	2005
4	Fracture Mechanics by E. E. Gdoutos, 2 nd ed., Springer International Publishing, Springer Nature Switzerland AG.	2005
5	Elementary Fracture Mechanics, S. A. Meguid, 1 st ed., Springer Netherlands,	1989
6	Introduction to Fracture Mechanics, Kare Hellan, McGraw Hill Book Company.	1985
7	e-book on Engineering Fracture Mechanics: K Ramesh, Published by IIT Madras, India, URL: https://apm.iitm.ac.in/smlab/kramesh/book_4.htm	2015

Course Name	:	MODELING AND SIMULATION
Course Code	:	MEE1010
Credits	:	4
L T P	:	3-1-0

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
1	INTRODUCTION: System, environment, input and output variables, State variables, Static and Dynamic systems, Hierarchy of knowledge about a system and modeling strategy, <i>Physical Modeling:</i> Similarity criteria and their application.	8
2	MODELING OF SYSTEM: Review of conservation laws and governing equations of heat, mass and momentum transfer, <i>Deterministic model:</i> Distributed parameter models in terms of partial identification and their solutions, Lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control.	10
3	SYSTEM SIMULATION: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages.	8
4	SYSTEM DYNAMICS: Growth and Decay models, Logistic curves, System dynamics diagrams, <i>Probability Concepts in Simulation:</i> Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs.	8
5	SIMULATION OF MECHANICAL SYSTEMS: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic and pneumatic systems, Simulation of waiting line systems, Job shop with material handling and flexible manufacturing systems, Simulation software for manufacturing, Structure and development of expert systems.	8

Sr. No.	Course outcomes: By the end of this course, the student will be able to	KnowledgeLevel (Blooms Level)
1	Recall the conservation laws and governing equations of heat, mass and momentum transfer.	L1
2	Understand various systems and their input/output and state variables.	L2
3	Apply the concepts of physical and deterministic models for modelling of systems.	L3
4	Analyse and evaluate various system simulation techniques and feedback control systems.	L4
5	Generate and evaluate the system equations using different modelling techniques.	L5 & L6
6	Develop mechanical systems and perform its simulations.	L3 & L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1	-	-	-	-	-	-	-	1	1	1
CO2	2	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	1	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	1	-	-	-	-	-	-	1	3	1
CO6	3	3	3	3	2	-	-	-	-	-	-	1	3	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Principles of Modeling and Simulation: A Multidisciplinary Approach, John A. Sokolowski and Catherine M. Banks, Elsevier.	2009
2	Theory of Modeling and Simulation, Zeigler B.P. Praehofer and I.G. Kim, 2 nd ed., Academic press.	2000
3	System Dynamics, Modeling and Simulation of Mechatronic Systems, D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, John Wiley & Sons, NY.	2018

Course Name	:	KINEMATICS AND DYNAMICS OF ROBOTS
Course Code	:	MEE1011
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To impart the knowledge about anatomy of the robots.
2	To demonstrate the concepts of kinematics & dynamics of robot.
3	To demonstrate the robot programming and their applications in industrial robots.
4	To provide the knowledge of how industrial robots' functions.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION OF ROBOTICS: Definition of a robot, Robot Anatomy, types of robotic joints and motions, <i>Classifications of robot</i> : Physical configurations, actuators and motion control, Terminologies used for robotics specification and selection for industrial applications, Design and Control issues, manipulation and control, end effector.	5
2	COORDINATE FRAMES, MAPPING AND TRANSFORMS: <i>Coordinate frames</i> : Mapping between rotated frames, Mapping between translated frames, Mapping between combined rotated and translated frames, Description of objects in space, Transformation of vectors, composite transformation, inverting a homogeneous transform, <i>Fundamental rotation matrices</i> : Principal axes rotation, fixed angle representation, Euler angle representation, equivalent angle axis representation.	7
3	ROBOT KINEMATICS: Mechanical structure and notation, description of links and joints, kinematic modeling of the Robot, Denavit-Hartenberg notation, Kinematic relationship between adjacent links, Robot transformation matrix, forward and inverse kinematics for basic industrial robotic configurations.	8
4	JACOBIAN FOR VELOCITY AND STATIC FORCES: Notation for time varying position and orientation, linear and rotational velocity of rigid bodies, angular velocity, motion of the link of a robot, velocity propagation of link to link, Jacobians, singularities, static forces in robots, Jacobian in the force domain, Cartesian transformation of velocities and static forces.	6
5	ROBOT DYNAMICS: Introduction to Lagrangian mechanics and Dynamic equation for 2 DOF robots, Introduction to position control and force control of robotic robots, Robot actuation and control using PID controllers.	6
6	ROBOT PROGRAMMING: Programming methods, Robot language classification, Robot language structure, elements and its functions, Motion, End-effector and sensor commands in VAL programming language.	4
7	ROBOT VISION: Sensing and digitization of vision data, <i>Image Processing</i> :	6

	image data reduction, segmentation, feature extraction, object recognition and training of vision system.	
--	---	--

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understand the basics concepts of robots and apply the transformations for mapping of frames and axis rotations	L2 & L3
2	Develop the forward and inverse kinematics of robots.	L6
3	Analyze the forces in links and joints of a robot.	L4
4	Apply the Lagrange equation to evaluate the dynamics of a robotic arm.	L3 & L5
5	Understand the robot vision and robot Programming methods and language to perform tasks in industrial applications.	L2
6	Ability to program a robot for different robot configuration to perform different tasks.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	-	-	-	-	-	-	1	3	1
CO2	3	2	2	3	-	-	-	-	-	-	-	1	3	2
CO3	3	2	2	2	-	-	-	-	-	-	-	1	3	2
CO4	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO6	1	1	1	1	-	1	-	-	-	-	-	1	2	2

List of experiments	No. of Turns
The experiment work in this course is intended to be carried out in the area of basic of Industrial Robotics, Robot Analyzer for learning different robot configuration, robot kinematics and programming in the Simens CoE Robotics Lab.	14

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fundamental concepts and analysis, Ashitava Ghosal, Robotics, Oxford University Press.	2006
2	Robotics Control, Sensing, Vision and Intelligence, K. S. Fu, R. C. Gonzalez, C. S. G. Lee, McGraw-Hill.	1987
3	Introduction to Robotics: Mechanics and Control, John. J. Craig, PHI.	2005
4	Robotic Engineering An Integrated Approach, R. D. Klafter, T.A. Chmielewski, M. Negin, PHI.	2007
5	Fundamentals of Robotics: Analysis & Control, Robert J. Schilling, Pearson Education.	2000
6	Robotics, K. K. Appuu Kuttan, I K Internationals	2013

Course Name	:	PRECISION ENGINEERING
Course Code	:	MEE1012
Credits	:	4
L T P	:	3-0-2
Course Objectives:		
1. To understand the concept of precision engineering and its principles. 2. To familiarize the importance as applicable to instruments and machines. 3. To familiarize with MEMS-principle, elements-characteristics-design and application. 4. To familiarize with the nanotechnology and electrochemical atomic bit processing.		

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	CONCEPT OF PRECISION ENGINEERING: Introduction to accuracy & precision, need and applications of precision engineering, Tool based Micro & Ultra precision processes, Materials for tools and machine elements, ceramic, CBN & diamond micro tools.	6
2	ULTRA-PRECISION MACHINE ELEMENTS: Introduction of Guide ways, Drive systems, Spindle drive, preferred numbers, Rolling elements, hydrodynamic & hydrostatic bearings, pneumatic bearing.	6
3	MEMS: Introduction, Principle, Elements, Characteristics, Design, applications in automobile, defense, aerospace, medical sectors.	6
4	ERROR CONTROL: Error, Sources, Static stiffness, Variation of the cutting force, total compliance, <i>Machining methods:</i> milling, drilling, grinding; <i>Thermal effects:</i> heat source, heat dissipation, Stabilization, decreasing of thermal effects; effects of forced vibration on accuracy, clamping & setting errors, errors due to locations and Control, principle of constant location surfaces.	7
5	SURFACE ENGINEERING: Surface finish, Relationship between attainable tolerance grades and different machining processes, Cumulative effect of tolerances, sure fit law, normal law and truncated normal law related to surface finish.	5
6	FUNDAMENTALS OF NANOTECHNOLOGY: System of nano-meter accuracies, Mechanism of metal Processing, Nano physical processing of atomic bit units, Nanotechnology and Electrochemical atomic bit processing.	6
7	MEASURING SYSTEMS: In-processing and in-situ measurement of position, Post process and on-machine measurements, dimensional, mechanical and optical measuring systems.	6

List of practical's / mini-projects		No. of Turns
1	Experiments on Micro EDM and analysis of accuracy & precision of machined surface finish	4
2	Mini project on MEMS.	4
3	Micro gear cutting and analysis of accuracy, clamping & setting errors.	3
4	Grinding analysis of thermal effects.	3

Sr. No.	Course outcomes: By the end of this course, the student will be able to	KnowledgeLevel (Blooms Level)
1	Understanding the concept and need for Precision Engineering.	L2
2	Apply the concept of precision engineering and its principle in the ultra-precision domain.	L3
3	Analyze the tolerance grades and physical processes applied to surface engineering.	L4
4	Design the various components of MEMS for different industries.	L6
5	Measure and Judge to select different measuring systems used in precision engineering.	L5
6	Estimate the error and analyse the thermal effects on machining methods applied to manufacturers of precision components.	L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1	1	-	-	-	-	-	-	1	1	1
CO2	2	1	1	1	2	-	-	-	-	-	-	1	2	1

CO3	2	2	2	2	2	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	2	-	-	2	3	2
CO5	2	2	2	2	3	-	1	-	-	-	-	2	2	3
CO6	3	3	3	2	3	-	2	-	-	-	-	2	3	2

Text Books:		
Sr. No.	Name of the Book/ Authors/Publisher	Year of Publication/ Reprint
1.	Nakazawa, H. Principles of Precision Engineering, Oxford University Press,	1994
2.	Basics of Precision Engineering, Richard Leach, Stuart T. Smith	2021
3.	Nano Technology, Norio Taniguchi, Oxford University Press.	1996
4.	Precision Engineering in Manufacturing, Murthy R. L., New Age International (P) Limited.	1996
5.	Geometric Dimensioning and Tolerancing, James D. Meadows, Marcel Dekker Inc.	1995
6.	Basics of Precision Engineering, Richard Leach, Stuart T. Smith, CRC Press	2021

Course Name	:	AUTOMOTIVE COMBUSTION AND EMISSIONS
Course Code	:	MEE1013
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To understand the basics of combustion.
2	To acquire the knowledge of stages of combustion in IC engine.
3	To acquire the knowledge of kinetics of combustion used particularly in combustion chamber design.
4	To understand the formation of pollutants and its mitigation principles

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Engine Combustion and Emissions	2
2	THERMODYNAMICS OF COMBUSTION: Combustion Stoichiometry, Heat of Reaction, Enthalpy of Formation, Adiabatic Flame Temperature, Equilibrium Combustion Products, Unburned Mixtures, Low Temperature Combustion Products, High Temperature Combustion Products, Chemical Kinetics	5
3	COMBUSTION IN SI ENGINES: Premixed Charge Combustion, SI Engine Combustion Conceptual Models, Combustion Rate Characterization, Thermodynamics Analysis of Combustion, Cycle-To-Cycle Combustion Variations, Knocking Combustion	6
4	COMBUSTION IN CI ENGINES: Fuel Injection and Spray Structure, CI Engine Combustion Conceptual Models, Diesel Combustion Process Characterization, Thermodynamic Analysis	4
5	ENGINE COMBUSTION SYSTEMS: Fluid Motion in Engine Cylinder, Valve Arrangement and Variable Valve Actuation, Classification of Engine Combustion Systems, Premixed Homogeneous Charge SI Engines, Direct Injection Stratified Charge Engines, Heterogeneous Charge CI Engines, HCCI/CAI Engines, Engine Management and Sensors, Laser diagnostic and optical measurement.	6
6	FORMATION OF ENGINE EMISSIONS: Emission effect on health and environment, sources of engine emissions, formation of carbon monoxide, NO formation, unburned hydrocarbon emissions, soot and particulate formation, diesel NO _x - particulate trade off, effect of SI engine design and operating variables, effect of diesel engine design and operating variables.	5

7	EMISSION STANDARDS AND MEASUREMENT: Emission Standards, Emission Test Cycles, Emission Measurement: Instrumentation and Methods, Euro/Bharat Stage norms.	2
8	EMISSION CONTROL TECHNOLOGY: <i>SI Engine</i> -Design Parameters, Add-On Systems for Treatment of Emissions Within Engine, Exhaust After-treatment, Direct Injection Stratified Charge (DISC) Engines, Summary of SI Engine Emission Control. <i>CI Engine</i> - Design Parameters, Application of EGR in CI Engines, Exhaust After-treatment in Diesel Engines, Summary of Diesel Emission Control, HCCI Engines for Emission Control.	6
9	ENGINE FUELS AND EMISSIONS: Common Hydrocarbon Components, General Fuel Quality Requirements, Motor Gasoline, Diesel Fuels, Alternative Fuels, antiknock fuels, Alcohols, Natural Gas, Liquefied Petroleum Gas, Biodiesel, Gas-to-Liquid (GTL) Fuels, Dimethyl Ether (DME), Hydrogen, Greenhouse Gas Emissions, various fuel additives	6

S. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Bloom Level)
1	Apply the basic concepts of combustion in automotive engine combustion, and understand the emission standards.	L2 L3
2	Interpret the process of combustion in automotive engines.	L3
3	Analyze and examine the combustion process, and measurement techniques, and challenges.	L4 & L5
4	Select the suitable fuel for the current and future needs of the society.	L5
5	Design the engines to minimize the emissions with suitable control strategies.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Internal Combustion Engines Fundamentals, John B. Heywood, McGraw Hill Science	2000
2	Combustion and Emissions in IC Engines, Murari Mohan Roy (Published Independently with Amazon)	2019
3	Internal Combustion Engines: Performance, Fuel Economy and Emissions, IMechE, London, Elsevier.	2013
4	IC Engines: Combustion and emissions, B P Pundir, Alpha Sciences.	2010

Course Name	:	COMPUTATIONAL FLUID DYNAMICS
Course Code	:	MEE1014/MEM1003
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To understand mathematical characteristics of partial differential equations.
2	To understand basic properties of computational methods.
3	To learn computational solution techniques for time integration of ordinary and partial differential equations.
4	To learn to solve computationally the Euler and Navier-Stokes equations
5	To acquire basic programming and graphic skills to conduct the flow field calculations and data analysis.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1.	INTRODUCTION: CFD and its Applications, Numerical vs Analytical vs Experimental approach, Modeling Vs Experimentation, Fundamental principles of conservation, Reynolds transport theorem, Principles of mass, momentum and energy conservation, General scalar transport equation.	4
2.	PARTIAL DIFFERENTIAL EQUATIONS AND PHYSICAL BEHAVIOUR: Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Applications of elliptic, parabolic and hyperbolic partial differential equations	2
3	ORDINARY DIFFERENTIAL EQUATIONS: Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations.	3
4	FUNDAMENTALS OF DISCRETIZATION: Pre-processing, Solution, Post-processing, Finite difference method (FDM), Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportive Ness, Finite volume method (FVM), Illustrative examples:1-D steady state heat conduction without and with constant source term. 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. The basic structure of a CFD code: Pre-processor, Solver and Post-processor, User-defined-subroutines, Solution to some basic problems in heat transfer and fluid flow.	6
5	FINITE VOLUME METHOD: Concepts and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion-based problem, Composite material with position dependent thermal conductivity, Source term linearization, Implementation of boundary conditions. FVM for 2-D unsteady state diffusion problems. <i>Finite volume discretization of convection-diffusion problem:</i> Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme. Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm.	14
6	DISCRETIZATION OF TIME DEPENDENT DIFFUSION TYPE PROBLEMS: Consequences of time-discretization in finite discretization, Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent	7

	and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): Forward time central space (FTCS) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): Central time central space (CTCS) scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Stability analysis of 2 nd order hyperbolic equations: CTCS scheme.	
7	LINEAR ALGEBRAIC EQUATIONS: Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: L-U decomposition technique, Tridiagonal matrix algorithm (TDMA): Thomas algorithm, Illustrative examples, <i>Iteration methods:</i> Jacobi's method and Gauss Siedel method, Illustrative examples of Jacobi's method and Gauss-Siedel method, ADI (Alternating direction implicit) method.	6

List of Experiments		No. of Turns
1	Ansys Simulation of lid driven cavity.	2
2	Ansys Simulation of heat transfer and fluid flow through pipe.	2
3	Ansys Simulation of flow past regular and irregular bodies.	2
4	Ansys Simulation of Conduction, Convection and Radiation	2
5	Ansys Simulation of flow through porous media.	3
6	Ansys Simulation of Phase Change Materials	3

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understand the use and stepwise procedure to completely solve a fluid flow and heat transfer problem using computational methods.	L1, L2
2	Develop basic governing equations for fluid flow and heat transfer by examining the physical boundary conditions.	L3
3	Construct and analyze the consistency, stability and convergence of various discretization schemes of finite difference-based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem.	L4, L6
4	Predict and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3-dimensional fluid and heat transfer problems.	L3, L5
5	Analyze and evaluate various finite volume based CFD schemes to solve fluid and heat transfer problems.	L3, L5
6	Practice CFD software to simulate practical fluid flow and heat transfer problems	L3

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	-	-	-	-	1	3	2
CO2	2	3	3	2	1	-	-	-	-	-	-	1	2	3
CO3	2	2	3	2	1	-	-	-	-	-	-	1	2	3
CO4	2	2	3	3	2	-	-	-	-	-	-	1	2	2
CO5	2	2	3	3	2	-	-	-	-	-	-	1	2	2
CO6	2	2	2	2	3	-	-	-	-	3	-	2	2	3

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Numerical Heat Transfer and Fluid Flow, S. V. Patankar, McGraw-Hill.	2018

2	Computational Fluid Dynamics, T. J. Chung, Cambridge University Press.	2010
3	An Introduction to Computational Fluid Dynamics, H. K. Versteeg & W. Malalasekera, 2 nd ed. Longman Scientific & Technical	2007
4	Computational Methods for Fluid Dynamics, J. H. Ferziger and M. Peric, 3 rd ed. Springer	2002
5	Computational Fluid Mechanics and Heat Transfer, John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, 3 rd ed., Taylor & Francis	2016
6	Computational Fluid Dynamics, John D. Anderson Jr, McGraw Hill Book Company	2017
7	Computational Fluid Dynamics: Principles and Applications, J. Blazek, 3 rd ed. Elsevier.	2015

Course Name	:	INDUSTRIAL AUTOMATION
Course Code	:	MEE1028
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To understand the principles, strategies and advantages of industrial automation.
2	To impart the knowledge about PLC programming for a given task.
3	To demonstrates problem-solving skills in automation with circuits design.
4	To impart the knowledge about the practical methods of automatic control of advance machines, critical processes and systems.

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
1	AUTOMATION: Concepts, Need and Demand of automation, Current and future Trends, Components of Industrial Automation System and their functionalities, Levels and Types of Automation, Mechanization vs Automation, strategies of automation, Current emphasis in automation.	6
2	AUTOMATION CONTROLLERS: Introduction of Industrial Controllers, Programmable Logic Controller: Constructions, Types, Programming Units, Memory, I/O Modules, Programming methodology, Ladder Logic programming and diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.	6
3	LOGIC CONTROL CIRCUITS FOR HYDRAULICS AND PNEUMATICS: Basic elements of hydraulics and pneumatics, fluid power control elements and standard graphical symbols, hydraulic & pneumatic cylinders and valves for pressure, flow & direction control, Circuit design approach and real time examples, sequence operation of two and more than two cylinders, Hydraulic and pneumatic safety and their applications in clamping, traversing and releasing operations.	6
4	INDUSTRIAL CONTROL SYSTEM: Process versus discrete manufacturing, continuous versus discrete control, computer process control, forms of computer process control, closed loop versus open loop control, design of control systems, levels of automation in industries, variables and parameters in industries.	6
5	ELECTRICAL AND ELECTRONIC CONTROL: Sensor Terminology, classification of sensor and transducer, their selection, temperature, light, position, piezoelectric, pressure and vision sensors, acoustic emission sensing techniques, microprocessor, microcontroller.	6

6	FACTORY AUTOMATION: Fundamentals of production lines, types of assembly lines, reasons for using automated assembly lines, transfer systems in assembly lines, automatic machines, transfer devices and machines, selection of transfer devices, linear and rotary transfer mechanism, classification, conveyors, Feeders: classification, selection criterion, feeding devices, Types of feeders: reciprocating, vibratory, screw, rotary, centrifugal, flexible, Automated guided vehicles.	6
7	MATERIAL HANDLING SYSTEMS AND DESIGN: Introduction to Material Handling, Material Transport Equipment, analysis of Material Transport Systems, Storage systems, Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment, Automation Storage Systems, Engineering Analysis of Storage Systems.	6

Sr. No.	Experiments	No. of Turns
1	Students in a group will carry out projects on design and implementation of an automatic modular system which can be useful in contemporary automation industries. The methodologies will be followed the design and simulation of automated systems using software and implementation via pneumatic controls, electro-pneumatic controls, PLC and motion controls in Simens CoE Labs, PEC, Chandigarh.	14

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the concept, need and demand of automation.	L2
2	Apply the principles, strategies and advantages of automation.	L3
3	Select the level and types of factory automation.	L3
4	Categories the material handling system for modern automated industry.	L4
5	Justify the uses of various automation controllers in real life time industrial application.	L5
6	Design the logic control circuits for hydraulics and pneumatics operated automation systems.	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	-	1	-	-	-	-	1	2	1
CO2	3	3	2	2	-	-	2	-	-	-	-	1	3	1
CO3	3	2	2	1	-	-	2	-	-	-	-	1	3	2
CO4	2	3	2	3	2	-	2	-	-	-	2	1	3	3
CO5	1	2	2	3	2	1	-	-	-	-	1	1	1	2
CO6	1	2	3	2	2	1	1	-	-	-	-	1	2	3

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Automation production Systems and Computer Integrated Manufacturing, Groover, M.P., Pearson Education	2009
2	Computer Based Industrial Control, Krishna Kant, Prentice Hall of India, New Delhi.	2010
3	Mechatronics, W. Bolton, 5 th ed., Addison Wesley Longman Ltd	2010
4	An Introduction to Automated Process planning Systems, Tiess Chiu Chang and Richard A.W., Tata McGraw-Hill Publishing company, New Delhi	2000
5	Automated Manufacturing Systems, Morriss, S. B., McGraw Hill.	2006
6	Advanced Industrial Automation and Its Applications, Ravindra Sharma, Laxmi Publications Pvt Ltd	2021

Department Elective Courses-III

Course Name	:	FINITE ELEMENT METHOD IN ENGINEERING
Course Code	:	MEE1015
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To learn basic principles of finite element method as a numerical tool in engineering analysis & design procedure.
2	To learn the theory and modeling of finite elements that represent engineering structures.
3	To learn finite element solutions to structural & dynamic problems through hands-on and simulation exercises.
4	To impart the knowledge and skills needed to effectively evaluate and interpret finite element analysis.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Introduction to FEM and historical background, Brief overview of the steps used in FEM, Various approaches to formulate elemental equations, Difference among FEM, FDM and closed form solutions, Need to study FEM, Review of the concept of stresses, strains, displacements and their relations, Von-Mises stresses, equilibriums, boundary conditions, temperature effect, Concept and application of Minimum Potential energy method, Rayleigh Ritz method, Galerkin Method and Principle of Virtual Work as applied to elasticity problems.	6
2	MATRIX ALGEBRA & GAUSS ELIMINATION METHOD: Matrix algebra and its different operations, Special feature of matrix algebra useful to FEM, Eigen values and Eigen vectors, Positive definite matrix, Gauss elimination method to solve large linear equations.	2
3	1-D PROBLEMS: Introduction, finite element modelling using bar element, shape functions, Iso, super and sub parametric FEM formulation, Potential energy approach to solve 1-D problems, assembly of elemental equations, Properties of global stiffness matrix, types and applications of boundary conditions, higher order 1-D element and their shape functions, its application to 1-D problem, Accounting of temperature effect in 1-D problems.	8
4	TRUSSES PROBLEMS: Introduction, 2-D and 3-D trusses, concept of local and global coordinate system and its transformation matrix, solution of 2-D and 3-D trusses, stress calculations, Accounting of the temperature effect.	4
5	2-D PROBLEMS USING CONSTANT STRAIN TRIANGLES (CST): Introduction, finite element modelling using CST elements and shape functions, Potential energy approach, solution of 2-D problems, Accounting of temperature effect, Problem modelling and boundary conditions for symmetrical problems, orthotropic materials.	6
6	2-D ISO-PARAMETRIC ELEMENTS AND NUMERICAL INTEGRATION: Introduction, Four-noded quadrilateral element-based FE Modelling and its solution, Numerical integration, Concept of weights and Gauss points and its values, Formulae, 2-D & 3-D numerical integration and applications, Higher order quadrilateral and triangular elements and its numerical integration.	6
7	BEAMS AND FRAMES: Introduction, Potential energy-based FE formulation using beam and frame elements, Boundary consideration, shear stress and bending moment, beams on elastic supports, plane frames, 3-D frames.	6
8	DYNAMIC PROBLEMS: Introduction, mass matrix as used in the FEM, elemental mass matrix for different types of elements as studied above, Evaluation of Eigen values and Eigen vectors.	4

Sr. No.	List of experiments	No. of Turns
1.	Static Structural analysis of plane frame using FEA software.	1
2.	Static Structural analysis of cantilever beam using FEA software.	1
3.	Static Structural analysis of plate with a hole using FEA software.	1
4.	Static Structural analysis of a stepped shaft in axial tension using FEA software.	1
5.	Static Structural analysis of bike crank using FEA software.	1
6.	Static Structural analysis of a four-point bend test on a T-beam using FEA software.	
7.	Static Structural analysis of three-dimensional analysis of combined loading in a signpost using FEA software.	1
8.	Static Structural analysis of planar approximations for a two-dimensional beam using FEA software.	1
9.	Static Structural analysis of a non-slender cantilever beam under point tip loading using FEA software.	1
10.	Static Structural analysis of Hoop and axial stresses in thick-walled pressure vessels using FEA software.	1
11.	Optimization of plate with a hole using FEA software.	1
12.	Modal Analysis of cantilever Beam using FEA software.	1
13.	Modal Analysis of a Wing using FEA software.	1
14.	2D Steady Conduction analysis for a Rectangular Domain using FEA software.	1

Course outcomes: After successful completion of this course, students will be able to	Knowledge (Blooms Level)
1. Apply the concepts behind various formulation methods used in FEM.	L3
2. Identify and select suitable type of elements for a problems and generation of global equations.	L1 & L5
3. Identify and apply boundary conditions to global equations and to solve these equations.	L1 & L3
4. Interpret the output of FEM based software in more meaningful manner.	L2

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication / Reprint
1	Introduction to Finite Elements in Engineering, Chandrupatala & Belegundu, 4 th ed., Pearson.	2015
2	Finite Element Method, J. N. Reddy, 2 nd ed., McGraw Hill.	1993
3	Concept & Application of Finite Element Analysis, Cook et al., 4 th Ed., John Wiley.	2004
4	The Finite Element Method for Engineers, Huebner et al., 3 rd ed, John Wiley.	1982
5	Finite Element Analysis (Theory & programming), C. S. Krisnamoorthy, 2 nd ed., Tata McGraw Hill.	2017

Course Name	:	HYDRAULIC AND PNEUMATIC CONTROL DESIGN
Course Code	:	MEE1016/MEO1002
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
2	To understand the concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
3	To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
4	To provide the exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
5	To familiarize with logic controls and trouble shooting.

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
8.	BASIC PNEUMATIC AND HYDRAULIC SYSTEMS: Introduction and basic elements of fluid power system, their structure, advantages and limitation, Applications of fluid power, pneumatic vs hydraulics control systems, Properties of fluids for hydraulic systems and governing laws, review of pneumatics in distribution of fluid power, Structure and signal flow of hydraulic and pneumatic system, Basic types and constructions of hydraulic pumps, motors and compressors, Air generation and distribution, Processing elements, Power components.	5
9.	FLUID ACCESSORIES: Air receiver, after-cooler, Air Dryer, Air Filter, Pressure Regulator, Air Lubricator, Air Service Unit, Pipeline layout, Seals, Hydraulic fluids, Hydraulic reservoir, Hydraulic filter, Hydraulic Accumulator, Intensifier, Pressure gauges and Volume Meters, Lines, Fitting and Connectors, Hydraulic seals.	5
10.	ACTUATORS AND OUTPUT DEVICES: Cylinders, Classification of cylinders on the basis of construction, Single and Double acting cylinders, their types, <i>Classification of cylinders on the basis of working Medium:</i> hydraulic and Pneumatic, rod-less cylinders, Cylinder construction, mounting arrangement Construction and working of rotary actuators such as gear, vane, piston and hydraulic motors. Theoretical torque, power, flow-rate, hydraulic motor performance, Symbolic representation of actuators (cylinders and motors), Cylinder performance characteristics, Symbols of Motors, Classification of fluid motors.	5
11.	CONTROL ELEMENTS: Classification of the valves, Direction Control valves, Poppet valves, Function of a 3/2-way NC and NO poppet valve, Manual and Mechanical operation of poppet valves, Mini poppet valves, 3/2-way and 5/2-way spool valves, Manual and mechanical operating devices for spool valves, Pneumatic operating devices for the valves , Directly operated solenoid valves , Servo solenoid valves with internal pilot and external pilot, Three-position valves, <i>Blocking valves:</i> Unidirectional, bidirectional, Signal processing valves, Nominal flow rate, Sizing of directional control distribution valves and connecting tubes, Interception valves, Non return, Flow and Pressure valves, Valve combination, Quick exhaust valve, Time delay Valve/Air Timer, Pneumatic Logic Valves, Twin Pressure valve, Shuttle Valve, Symbolic representation.	8

12.	DESIGN OF HYDRAULIC CONTROL CIRCUIT: Symbols and description of components, Rules for designing circuits, Control chain, design of circuit diagram, circuit layout, designation of individual elements, Single or semi-automatic cycle, Continuous or automatic cycle, Elementary circuits, Signals generated by limit switches, Hydraulic circuit for control of single acting and double acting cylinder, Speed control in hydraulic circuits, Bleed of circuit, Regenerative circuit, Sequencing circuit, hydraulic circuit for force multiplication, speed control of hydraulic cylinder- metering in, metering out and bleed off circuits, Pilot pressure operated circuits, Hydraulic circuit with accumulator, counter balance valve application, Memory valves, Timer, Cycle start command, Single and continuous cycle, Emergency command pressure reduction circuit, problems in circuit design.	6
13.	DESIGN OF PNEUMATIC CONTROL CIRCUIT: Pneumatic Circuits for control of single acting and double acting cylinder, <i>Simple Pneumatic Control:</i> Direct and indirect actuation pneumatic cylinders, speed control of cylinders, supply air and exhaust air throttling, Circuit with mechanical feedback, Use of flow control valve and Quick exhaust valve, Time delay circuit, Circuit with necessary conditions, Application of Twin pressure and Shuttle valve, <i>Signal Processing Elements:</i> Use of Logic gates, OR and AND gates in pneumatic application, Practical examples involving the use of logic gates, <i>Electro-Pneumatic Control:</i> Principles, signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors, Control circuitry for simple signal cylinder application.	7
14.	CONTROL SYSTEMS: Open and closed loop control system, Selection and comparison of working and control media, Control Theory, <i>Control system development:</i> Positional sketch, Displacement, step diagram, Control Chart, Function Diagram, Function chart, Circuit diagram, Cascade Design, Steps involved in cascade design, Sign Conventions, Development aspects, Emergency control.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Recall basic elements of fluid mechanics and logic gates	L1
2	Identify and analyze the functional requirements of a fluid power transmission system for a given application.	L2 & L4
3	Understand the working of hydraulic/pneumatic circuit to accomplish the desired function.	L2
4	Design an appropriate hydraulic/pneumatic/combination circuit like electro-hydraulics, electro-pneumatics for a given application.	L6
5	Select and standardize the different components of the circuit.	L5
6	Apply the control systems development techniques in industrial applications.	L3

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	2	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	2	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO6	3	3	3	3	-	-	-	-	-	-	-	1	3	1

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fundamentals of Fluid Power Control, John Watton, Cambridge University press.	2012
2	Hydraulics and Pneumatics, Andrew Par, Jaico Publishing House.	2005
3	Fluid Power with Applications, Anthony Esposito, Pearson.	2000
4	Introduction to Fluid Power, Thomson, Prentice Hall.	2004
5	Pneumatic systems – Principles and Maintenance, Majumdar S.R., Tata Mc-Graw Hill, New Delhi.	2005
6	Oil Hydraulics, S. R. Majumdar, Tata Mc-Graw Hill.	2017

Course Name	:	AUTOMOTIVE ENGINEERING
Course Code	:	MEE1017/MEO1004
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To develop an understanding of all the sub-components of an automotive vehicle.
2	To give knowledge about all the controlling and electronic components.
3	To gain the knowledge about new technologies being used in automotive vehicles.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: History of Automotive engineering, Classification of Automotive vehicles, Different sub-systems in automotive vehicles, History of hybrid electric, electric and fuel cell vehicles, social and environmental importance of hybrid electric, electric and fuel cell vehicles.	2
2	COOLING AND LUBRICATION SYSTEMS: Cooling systems and its components for conventional and EV, anti-freeze mixtures. Lubrication purpose and various systems of lubrication, types and desirable properties of lubricants, components like oil filters, oil pumps, and oil pressure indicators, air supply system, air filters, turbo charger and super charger.	5
3	FUEL SUPPLY SYSTEMS: Fuel injection system for petrol and diesel engines, fuel pumps (mechanical and electrical), air fuel ratio requirements, carburetors: types and general operation throttle body and multipoint fuel injection systems, electronic control module and sensing devices.	5
4	TRANSMISSION SYSTEMS: Clutch function and types, torque converters; fluid flywheel; manual and automatic transmission/ trans axles; constant mesh & synchro-mesh gearboxes, epi-cyclic gearbox, differential, propeller shafts and universal joint front and rear axles. Basic concept of electric traction and architecture, Topologies for electric drive-train and their analysis, Drive cycle implications and fuel efficiency estimations and well to wheel fuel efficiency analysis, Sizing of components for different electric drive train topologies. Matching the electric drive and ICE, Transmission selection and gear step selection, Sizing the propulsion motor, its torque, constant power speed ratio and machine dimensions,	4
5	BRAKE SYSTEMS, WHEEL & TYRES: Braking efficiency and stopping distances. Types of brakes, Drum and disc brakes. Detailed description of hydraulic and pneumatic brake. Mechanical, vacuum and electrical methods of brake actuation,	5

	servo brakes, ABS, type of wheels, tyres, type of tyres; cross ply, radial tubeless etc. specification of tyres, Supporting system for EV braking system	
6	SUSPENSION SYSTEM: Road springs, shock absorbers, independent suspension, road springs, air suspension, hydro-elastic suspension.	4
7	STEERING SYSTEM: Steering geometry, details, correct steering angle, Ackerman steering mechanism. Cornering power, over steering and under steering. Worm wheel and Rack pinion types of steering gears. Safety steering columns, power steering, Supporting system for EV steering system.	5
8	IGNITION SYSTEM: Various ignition systems (coil and magneto) and detailed study of their components, electronic ignition system, distributor less ignition system	4
9	ENERGY STORAGE SYSTEM: Storage battery (lead acid type), Maintenance free batteries, various components, Charging system, Li-ion battery based energy storage and simplified models of battery, Fuel cells, their characteristics and simplified models, Super capacitor based energy storage, its analysis and simplified models, its advantages and challenges.	4
10	EMISSION CONTROL AND ACCESSORIES: Emission norm like EURO and BHARAT norms, methods and devices to control emissions; Automotive accessories, controlling devices such as fuel gauge, temperature gauge, indicator lights speedometer odometer, HVAC etc.	4

List of Experiments		No. of Turns
1	To study and prepare report on the constructional details, working principles and operation of the Automotive Engine Systems & Sub Systems.	2
2	To study and prepare report on the constructional details, working principles and operation of the Fuels supply systems.	1
3	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Clutches.	1
4	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Transmission systems.	2
5	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Drive Lines & Differentials.	2
6	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Suspension Systems.	1
7	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Steering Systems.	2
8	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Tyres & wheels.	1
9	To study and prepare report on the constructional details, working principles and operation of the conventional and EV Brake systems.	1
10	To study and prepare report on the constructional details, working principles and operation of conventional Automotive Emission / Pollution control systems.	1

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Realize the need and importance of study of automobile engineering for mechanical engineers.	L4
2	Identify and compare the relative merits, demerits and applications of different systems and components in an Automobile.	L3, L4
3	Explain working of IC engines (Gasoline and Diesel) and various parameters related to it.	L5
4	Classify and illustrate various elements of Automobile like, Transmission, Brakes,	L2, L4

	Suspension, and Steering etc.	
5	Explain recent advancements in field of Automobile engineering, like, Electric Vehicles, Hybrid Vehicles, CRDI engines, ABS etc.	L2
6	Explain and illustrate various emission and safety regulations along with their importance in automobile engineering.	L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	-	-	-	-	-	-	-	-	2	1	1
CO2	3	1	2	-	-	-	-	-	-	-	-	2	2	2
CO3	3	1	2	-	-	-	-	-	-	-	-	2	1	1
CO4	3	1	2	-	-	-	-	-	-	-	-	2	2	1
CO5	3	1	2	-	-	-	-	-	-	-	-	2	2	2
CO6	3	1	1	-	-	3	-	-	-	-	-	2	1	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Automobile Engg., Kirpal Singh, Standard Publication distributors, Delhi Vol. I & Vol. II	2020
2	Encyclopaedia of Automotive Engineering, D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Parts 1-6, Wiley	2015
3	Automotive Engineering Fundamentals, R. Stone and J. K. Ball, SAE International.	2004
4	The Motor Vehicle, T. K. Garrett, K. Newton, and W. Steeds, 13 th ed., SAE International.	2001
5	Internal Combustion Engines, V. Ganesan, 3rd Edition, Tata McGraw Hill.	2017
6	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, M. Ehsani, Y. Gao and A. Emadi, 2nd Edition, CRC Press.	2010
7	Car Suspension and Handling, D. B. Astow, G. Howard and J. P. Whitehead, 4th ed., SAE International.	2004
8	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley	2012

Course Name	:	WORK STATION DESIGN AND NEURO-ERGONOMICS
Course Code	:	MEE1018/MEO1001
Credits	:	4
L T P	:	3 1 0

Course Objectives:

1	This course is designed to teach the fundamentals of Designing of Ergonomically correct Work Stations
2	To study latest techniques used in the evaluation of human work in all contexts that leads systematically to the investigation of all the factors which affect the efficiency and economy of human energy at the work place
3	It helps in designing and improvement in the methods and procedures which are most effective, require the least efforts and are the best suited to the industrial workers.

Total No. of Lectures – 42

S. No.	Contents	No. of Lectures
1	WORK STUDY FUNDAMENTALS: Definitions, Scope and applications, Productivity and Work Study, Analysis of Work Content, Introduction to Industrial	3

	Engineering and Productivity, Measurement tools of productivity.	
2	METHOD STUDY: Process Analysis, Process and Activity Charts, Operation Analysis, Basic Procedure, Micro Motion Study, Principles of Motion Economy.	5
3	WORK MEASUREMENT: Purposes and Uses, Basic Procedure, <i>Techniques:</i> Work Sampling, Rating and Allowances, Setting Standard Times for Jobs, Standard Data, Predetermined Motion Time Systems, MTM, Work factor and MOST, Job Evaluation of Merit Rating, Wage Incentive Plans.	8
4	ERGONOMICS AND RISK ASSESSMENT: Concepts, Issues in Work System Design, Measuring Work by Physiological Means, Work Posture, Fatigue Measurement & Evaluation, Work Systems, Limitation of Man & Machine with respect to each other by risk assessment techniques such as RULA, REBA, OCRA, NIOSH, SI, PLIBEL, QEC and OWAS.	8
5	WORK LOAD MEASUREMENT: Human Motor Activity, Anatomy of human muscles and brain lobes, Metabolism, Physical and Mental Work load and their Measurement, Introduction to work related musculoskeletal disorders and mental fatigue, Introduction to Neuro-ergonomics and quantification of neuro-signals from electro-encephalography and electromyography by linear and non-linear techniques with respect to work duration and rest periods, Introduction to Digital Human Modelling Techniques.	10
6	CLIMATES AND NOISE EVALUATION: <i>Heat Humidity:</i> Body heat Balance, Effective Temperature Scales, Zones of Discomfort, Effects of Heat on Body and Work Performance, <i>Vibration:</i> Response of Body to Low Frequency Vibration, Vibrations and Discomfort, Effect on Health of Worker, Effect of High Frequency Vibrations, Methods of Reducing Vibrations, Analysis, <i>Noise:</i> Physiological Effects of Noise, Annoyance of Noise, Speed Interference, Hearing Loss, Temporary and Permanent Threshold Shift, Effect of Noise on Performance, Reduction of Noise, Personal Noise Protection.	8

Course outcomes: By the end of this course, the student will be able to:		Knowledge Level (Blooms Level)
1	Assess all industrial activities with respect to motion study and there by design work stations.	L5 & L6
2	Quantification of physical and mental work load of the workers by latest neurological techniques.	L5
3	Identify and assess the environmental and climatic working conditions in industry.	L2 & L5
4	Analyze and apply different risk assessment techniques to predict risk involved in work with respect to development of musculoskeletal disorders.	L3 & L4
5	Application of all latest time study techniques to calculate standard time to carry-out any industrial job.	L3

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Motion and Time Study, Design and Measurement of Work, Ralph M. Barnes,	2009

	Wiley India.	
2	Neuro-Ergonomics, Raja Parasuraman & Mathew Rizzo, Oxford University Press.	2007
3	Handbook of Digital Human Modelling, Vincent G. Duffy, CRC Press Taylor & Francis Group.	2009
4	Ergonomics Laboratory Exercises, Timothy Joseph Gallwey & Leonard William O' Sullivan, CRC Press Taylor & Francis Group.	2010
5	International Standard Manual of Ergonomics, Part-1: Lifting and Carrying; Part-2: Pushing and Pulling, Part-3: Handling of Low Loads at High Frequency.	2009
6	Neuroergonomics: Principles and Practice, Chang S. Nam, Springer	2020

Course Name	:	EXPERIMENTAL STRESS ANALYSIS
Course Code	:	MEE1019
Credits	:	4
L T P	:	3-1/2-2/2

Course Objectives: To understand the
<ol style="list-style-type: none"> 1.Relation between the theory of solid mechanics with experimental stress analysis. 2.Principles of photo elasticity in stress analysis. 3.Fundamental concepts about the experimental methods of stress analysis. 4.Use the experimental stress techniques on the practical problems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Stress at a point on an arbitrary plane in 3-D state of stress, differential equations of equilibrium, Laws of stress transformation, principal stresses and maximum shear stress, 2-D state of stress, displacement and strain, principal strains, compatibility conditions, stress-strain relations, Plane stress and plane strain problems, boundary conditions, Mohr's circle and stress plane, Three-dimensional stress-strain relations.	6
2	BASIC OPTICS: Basic concept and nature of light, polarization, decomposition of elliptically polarized light, passage of light through isotropic media and crystalline medium, normal incidence and oblique incidence, optic axis in refracting surface, absolute and relative phase difference, quarter and half wave plates, production of plane polarized light, light ellipse characteristics.	4
3	2-DIMENSIONAL PHOTOELASTICITY: Stress optics law, plane and circular polariscopes, isochromatics and isoclinics, white light and monochromatic light source, analysis of plane and circular polariscopes through trigonometric resolutions and Jones Calculus method, dark and bright field arrangement of circular polariscopes, isoclinics and isochromatics fringe order at a point, methods of compensation, calibration methods, use of white light in Photoelasticity, reversibility of optical system.	7
4	PHOTOELASTIC DATA COLLECTION, ANALYSIS AND APPLICATIONS: Photoelastic data, stress components, stress separation techniques and applications, properties of an ideal photoelastic material, casting technique, machining of photoelastic casting, stress relieving, 2-D and 3-D applications.	3
5	BIREFRINGENT COATING METHOD: Theory of Birefringent coatings, reflection polariscope, sensitivity of Birefringent coating, separation of principal stresses, sources of errors, Birefringent coating materials and applications.	4
6	MOIRÉ-FRINGEMETHODS AND ANALYSIS: Mechanism of formation of Moiré fringes, geometrical approach to Moiré-Fringe analysis, displacement field approach to Moiré-Fringe analysis for in-plane and out of plane problems, out of plane slope measurements, sharpening and multiplication of Moiré-Fringes, experimental procedure and techniques.	4

7	BRITTLE COATING METHODS: Brittle coating materials, Relation between the state of stress in coating and in the model, law of failure of brittle coatings and interpretation of crack-pattern data, Isostatics and Isoentatics, relative merits of stress coat and all temperature coating, Accuracy of brittle coating application, crack detection techniques, calibration of brittle coating materials.	4
8	STRAIN MEASUREMENT: Classification and brief over-view of the strain measurement devices, Electrical resistance strain gauge and types, gauge materials, backing material of strain gauge, adhesives used, bonding of strain gauge, checking accuracy of bonding, performance of strain gauge, strain gauge circuits, strain gauge rosettes.	6
9	DIGITIZATION OF PHOTOELASTICITY: Basic concepts and methodologies of digitization in photoelasticity, formulation of problems and applications, data acquisition by digital image processing techniques, data analysis by statistical techniques, data presentation by computer graphics.	4

List of experiments	No. of Turns
Students shall be practicing to solve the engineering problems using photo-elastic bench and other experimental methods of stress analysis.	7

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Evaluate stresses and strains by experimental methods.	L5
2	Elucidate the isoclinics and other fringe multiplication techniques.	L1, L2
3	Use experimental stress analysis methods including Moiré method etc.	L3, L5
4	Acquire the knowledge on brittle and birefringent coatings and working of strain gauges.	L2, L4

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Experimental Stress Analysis, L S Srinath, MR Raghavan, K Lingaiah, G Gargasha, B Pant, K Ramachandra, Tata McGraw Hill.	1984
2	Experimental Stress Analysis, Dally, J.W. and Riley, W.F, 3 rd ed., McGraw Hill Education.	1991
4	e-book on Experimental Stress Analysis: K Ramesh, Published by IIT Madras, India, URL: http://apm.iitm.ac.in/smlab/kramesh/book_5.htm	2009
5	Photoelastic Stress Analysis, Kuske A and G Robertson, John Wiley & Sons, London.	1974
6	Digital Photoelasticity - Advanced technique and application, K Ramesh, Springer-Verlag.	2000
7	Experimental Stress Analysis, UC Jindal, Pearson	2012
8	Applications and Techniques for Experimental Stress Analysis, Karthik Selva Kumar Karuppasamy, Balaji P.S, Business Science Reference	2019

Course Name	:	MECHANICS OF COMPOSITE MATERIALS
Course Code	:	MEE1020
Credits	:	4
L T P	:	3-1-0

Course Objectives:

1. To acquire basic understanding of composites materials.
2. To develop an understanding of the macro & micro mechanical analysis of a lamina.
3. To develop an understanding of the micromechanical analysis of laminates.
4. To impart the knowledge about the failure analysis and design of laminates.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION TO COMPOSITE MATERIALS: Introduction and Need of composite materials, <i>Classification of composite materials:</i> Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites, Characteristics of reinforcements and Matrix Materials, Recycling Fiber-Reinforced Composites, Mechanics Terminology.	6
2	MACRO MECHANICAL ANALYSIS OF A LAMINA: Definitions, Stress, Strain, Elastic Moduli, Strain Energy, Hooke’s Law for Different Types of Materials, Hooke’s Law for a 2-D Unidirectional Lamina, Reduction of Hooke’s Law from 3-D to 2-D, Relationship of Compliance and Stiffness Matrix to Engineering Elastic Constants of a Lamina, Hooke’s Law for a 2-D Angle Lamina, Invariant Form of Stiffness and Compliance Matrices for an Angle Lamina, <i>Failure Theories of an Angle Lamina:</i> Maximum Stress Failure Theory, Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai-Hill Failure Theory, Tsai–Wu Failure Theory, Comparison of Experimental Results with Failure theories. Hygrothermal Stresses and Strains in a unidirectional and angle Lamina.	11
3	MICRO-MECHANICAL ANALYSIS OF A LAMINA: Introduction, Volume and Mass Fractions, Density, Void Content, <i>Evaluation of the Four Elastic Moduli:</i> Strength of Materials Approach, Semi-Empirical Models, Elasticity Approach and Elastic Moduli of Lamina with Transversely Isotropic Fibers for various types of modulus, Ultimate Strengths of a Unidirectional Lamina for tensile, longitudinal compressive, transverse compressive and in-plane shear, Longitudinal and transverse Thermal Expansion Coefficients, Thermo-elastic Deformation Analysis, Coefficients of Moisture Expansion.	10
4	MICROMECHANICAL ANALYSIS OF LAMINATES: Introduction, Laminate Code, Stress–Strain Relations for a Laminate, One-Dimensional Isotropic Beam, Stress-Strain Relation, Strain-Displacement Equations, Strain and Stress in a Laminate, Force and Moment Resultants Related to Mid-plane Strains and Curvatures, In-Plane and Flexural Modulus of a Laminate, Hygrothermal Effects in a Laminate like Hygrothermal Stresses and Strains, Coefficients of Thermal and Moisture Expansion of Laminates, Warpage of Laminates.	9
5	FAILURE ANALYSIS AND DESIGN OF LAMINATES: Introduction, <i>Special Cases of Laminates:</i> Symmetric Laminates, Cross-Ply Laminates, Angle Ply Laminates, Anti-symmetric Laminates, Balanced Laminate, Quasi-Isotropic Laminates, Failure Criterion for a Laminate, Design of a Laminated Composites, Other Mechanical Design Issues, Sandwich Composites, Long-Term Environmental Effects, Inter-laminar Stresses, Impact Resistance, Fracture Resistance, Fatigue Resistance.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basics of Solid Mechanics.	L1
2	Understand the mechanical properties of various commercial composite materials.	L2
3	Analyze and evaluate the mechanical properties of Lamina at Macro and Micro level.	L4 & L5
4	Analyze and evaluate the mechanical properties of Laminates at Micro level.	L4 & L5
5	Develop a methodology for stress and progressive failure analysis of laminated composite structures to apply in aerospace, automobile, marine and other engineering applications.	L3 & L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Mechanics of Composite Materials, Autar K. Kaw, 2 nd ed., CRC Press.	2006
2	Mechanics of Composite Materials, Jones. R. M., Taylor & Francis Press	1999
3	Composite Material Science and Engineering, K.K. Chawla, 3 rd ed., Springer.	2012
4	Engineering Mechanics of Composite Materials, I.M. Daniel, O. Ishai, Oxford University Press.	2006
5	Analysis and Performance of Fiber Composites, B D Agarwal, L J Broutman, John Wiley and Sons. Inc., New York.	1995
6	Stress analysis of fiber Reinforced Composite Materials, Michael W, Hyer, McGraw Hill International.	2009
7	Composite Materials: Mechanics, Manufacturing and Modelling, Sumit Sharma, CRC Press	2021

Course Name	:	PRODUCTION PLANNING & CONTROL
Course Code	:	MEE1021
Credits	:	4
L T P	:	3-1-0

Course Objectives: To impart the knowledge about the:

1.	Concept and significance of Production planning & control.
2.	Plant capacity, location, layout and its applications.
3.	Routing, Scheduling, Purchasing and Dispatching.
4.	New trends in operations management used in industries.

Total No. of Lectures – 42

Lecture wise breakup		No. of lectures
1	INTRODUCTION: Objectives of production planning and control, functions and its advantages, types of controls and procedures.	4

2	PLANNING: Capacity planning, types of capacity plans, factors affecting the plant capacity, capacity planning strategies, investment decisions, comparison of alternatives, planning for making or buying, types of plans, mathematical planning techniques, analysis of machine capacity, planning for labour, aggregate production planning.	8
3	ROUTING: Definition, routing procedure including bills of materials, route sheet, route file, routing for two or more items, standard route chart and recent techniques of routing. SCHEDULING: Master schedule, departmental and shop schedule charts for scheduling, Gantt chart, loading and scheduling.	8
4	PURCHASING AND STORING: Planning for purchasing, procurement schedule, purchase requisition, calling tenders, comparative statements, placing orders, receiving materials, inspection entry and payment, foreign purchase: imports, documents and books. Location and layout of store-room, bins, racks, bar-codes and boxes used in storing, centralized and decentralized stores, functions of stores.	6
5	DISPATCHING: Procedure, types, MIS systems for department and shop, bulletin boards, move tickets, operation tickets, machine control boards, inspection ticket, time ticket, communication systems for dispatching, follow up.	4
6	PLANT LAYOUT AND LOCATION: <i>Plant layout:</i> objectives, principles and types, factors affecting plant layout, production line flow patterns, <i>Plant location:</i> factors affecting the selection of location. Location of factory in small town, suburban areas, location pattern of Indian industries.	6
7	NEW TRENDS IN OPERATIONS MANAGEMENT: Toyota Production System, Just in Time manufacturing, Kanban, lean manufacturing systems, Total quality management, Business process re-engineering, Logistics and supply chain management.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the concepts of 'Production planning & control' and aggregate production planning in Industries.	L2
2	Apply the Routing, scheduling and sequencing techniques used in industries.	L3
3	Apply the concepts of storing and purchasing procedure in various organizations.	L3
4	Choose the Dispatching procedure used in various industries.	L5
5	Design and develop the plant layouts using Design heuristics.	L6
6	Analyze the concepts new trends in operations management like TPS, JIT, TQM and SCM.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	2	1	1	-	-	-	2	1	1	2
CO2	2	1	1	1	2	-	2	-	-	-	2	1	1	1
CO3	2	1	1	-	2	-	2	-	1	-	2	1	1	2
CO4	1	1	1	2	1	-	1	-	1	-	-	1	1	1
CO5	2	1	1	1	2	1	2	-	1	-	-	1	1	1
CO6	1	1	1	-	3	1	1	-	-	2	3	1	1	2

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Industrial Engineering and Management, Hicks, Tata McGraw Hill, New Delhi	2003

2.	Production Control, John F. Biegal, Prentice Hall of India, New Delhi	1974
3.	Modern Production/Operation Management, Buffa and Sarin, John Wiley and sons	2015
4.	Industrial Engineering and Production Management, M. Mahajan, Dhanpat Rai and sons	2016
5.	Production & Operations Management, Surya Prakash Singh, Vikas publishing House Pvt. Ltd., Noida	2018

Course Name	:	HYDRAULIC MACHINES
Course Code	:	MEE1023
Credits	:	4
L T P	:	3-1/2-2/2

Course Objectives:	
1	Understand the basic principles of Hydraulic Machines.
2	To review the development of Hydel power plants and its eco-system.
3	Understand the working and design of hydraulic turbines and hydraulic pumps.
4	Basic understanding of various hydraulic systems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	HYDRO-ELECTRIC DEVELOPMENT: Development of water turbines, Types of water wheels, components of hydropower plant. Types of hydroelectric power plant. Types of turbine losses and efficiencies in hydraulic turbines.	3
2	PRINCIPLES OF HYDRAULIC MACHINES: Impulse Momentum equation, Impact of Jets Force on Stationery Plates, Force on moving plates force on series of vanes. Euler Equation for hydraulic machines, Degree of Reaction, Vortex motion and flow in turbine.	4
3	HYDRAULIC IMPULSE TURBINES: Components of Pelton Turbines, Dimension of bucket of Pelton turbine, Number of buckets Diameter of jets, speed ratio jet ratio, no. of jets, Energy conversion in Pelton turbines.	4
4	HYDRAULIC REACTION TURBINE: Evolution of Reaction turbines, Francis Turbine Draft tube, power losses and efficiencies of Francis turbine, Francis turbine proportions outward Vs inward flow reaction turbine. Axial flow turbines. Components of an axial flow turbine blade. Performance at part loads. Adjustment of Kaplan turbine, Kaplan turbine proportions Application of aerofoil theory.	7
5	GOVERNING OF HYDRAULIC TURBINES: Necessity of governing of hydraulic turbines, Requirements of a good governing system in hydraulic turbines, Essential elements of governing system, double regulation of turbines governing of Impulse turbines, governing mechanism of impulse and reaction turbines	3
6	PERFORMANCE OF HYDRAULIC TURBINES: Unit quantities, specific speed, characteristics of turbine, Types of characteristic curve, constant head characteristics, constant speed characteristics and instant efficiency or Muschel curve.	3
7	CENTRIFUGAL PUMPS: Classification of centrifugal pumps, components of centrifugal pump, working of centrifugal pump, Heads of pumps, Energy Conversion in centrifugal pump, variation of Euler's head with vane shapes. Effect of finite no. of vanes on Euler's head, losses and efficiencies, Minimum starting speed, Net positive suction head, Multi stage pumps, Pumps in parallel and series primary devices, concept of specific speed and performance of centrifugal pump Cavitation in Hydraulic pumps.	7
8	RECIPROCATING PUMP: Components and working of reciprocating pump, classification of reciprocating pump, Discharge through reciprocating pump, slip, Power input, Indicator diagram Effect of piston acceleration head on indicator diagram, Maximum speed of reciprocating pump, Arrangement of delivery pipe in	6

	reciprocating pump, air vessels, pressure head in cylinder with Air vessels during suction and delivery stroke, Maximum speed with air vessels comparison with centrifugal and Reciprocating pump	
9	HYDRAULIC SYSTEMS AND MACHINES: Hydraulic system, Hydraulic accumulator, Hydraulic intensifier, Hydraulic Jigger, Hydraulic lift Hydraulic Crane, Hydraulic Press, Hydraulic coupling Hydraulic Torque converter, Hydraulic pump Hydraulic Ram, Air lift pump, jet pump.	5

List of Experiments:		No. of Turns
1	To determine the characteristics curve of a Pelton wheel.	1
2	To determine the characteristics curve of a Francis turbine.	2
3	To determine the characteristics curve of a centrifugal pump.	2
4	To obtain the efficiency of a reciprocating pump under various heads.	1
5	To study the hydraulic ram and determine its efficiency.	1

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Recognize the basic fluid machineries and their components.	L2
2	Apply the basic principles of hydraulic machines.	L3
3	Analyze the performance of hydraulic machines.	L4
4	Determine the performance characteristics curves of hydraulic machines.	L5
5	Investigate and optimize the design parameters of hydraulic systems.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Hydraulic Machines by T.R. Banga and S. Sharma, Khanna Publisher	1995
2	Fluid Mechanics & Hydraulic Machines, SS Ratta, Khanna Publisher	2019
3	Theory and Design of Hydraulic Machines, V.P. Vasandani, Khanna Publisher.	1990
4	Fluid Mechanics and Hydraulic Machines, R.K. Rajput, S. Chand publisher.	2016

Course Name	:	DESIGN OF THERMAL SYSTEMS
Course Code	:	MEE1024/MEM1001
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To provide the knowledge of various mathematical techniques used in design and optimization of thermal systems.
2	To model and simulate the different thermal engineering problems.

3	To give an insight of a commercial software for modelling, simulation and optimization of the thermal systems.
---	--

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	ENGINEERING DESIGN: Design versus Analysis, Design versus Synthesis, Selection versus Design, Design as part of Engineering Enterprises, Basic Characteristics of Thermal System, Basic Consideration in Design, Conceptual Design, Basic steps in design process, Computer Aided Design of Thermal System, Material Properties and Selection for Thermal System.	07
2	MODELING OF THERMAL SYSTEM: Introduction, Types of Models, Mathematical Modeling, Physical Modeling and Dimensional Analysis, Importance of Modeling in Design, Basic Features of Modeling, Type of Models, General procedure of mathematical modeling, physical modeling and dimensional analysis.	07
3	NUMERICAL MODELLING AND SIMULATION: Numerical Model, Solution Procedure, Numerical Model of a System, System Simulation, Methods of Numerical Simulation.	07
4	ACCEPTABLE DESIGN OF THERMAL SYSTEM: Initial Design, Design Strategies, Design of System in different application areas such as manufacturing, electronics, environment, heat transfer and fluid flow, Additional Considerations in Large Practical Systems.	07
5	PROBLEM FORMULATION FOR OPTIMIZATION: Introduction to Optimization in Design, Basic Concepts, Optimization methods, Important Considerations for Optimization of Thermal System, Different Types of Thermal System, Practical Aspects of Thermal Design.	07
6	THERMAL SYSTEM ANALYSIS AND SIMULATION USING COMMERCIAL SOFTWARE: Modelling Periodic Flow and Heat Transfer, Laminar Flow Convection, Turbulent Forced Convection, Compressible Flow in Nozzle, Modelling Cavitation, Solidification and Steady and Unsteady Flow Past a Cylinder, Flat Plate Boundary Layer.	07

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	To have knowledge of different aspects of designing of a thermal system.	L1, L3
2	To identify and examine a design problem associated to a thermal system.	L4
3	To have understand basics of modeling and their associated techniques.	L6
4	To inculcate an ability to solve engineering problems using knowledge of various disciplines.	L7
5	To inculcate an ability to identify, formulates, and solves engineering problems.	L2, L5
6	Top inculcate an ability to use the mathematical tools for optimization of engineering problems.	L3
7	To design, formulate analysis and solve engineering problems using mathematical as well as commercial software tools.	L6
8	To explain economic and exergoeconomic aspects associated with designing and optimization of thermal system.	L4

CO-PO & PSO course Articulation Matrix

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

CO6	2	2	3	2	-	-	-	-	-	-	-	-	1	3
CO7	2	2	-	3	-	-	-	-	-	1	2	3	1	3
CO8	3	2	2	3	-	-	-	1	1	1	-	-	1	3

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Design and Optimization of Thermal System, Y Jaluria, 2 nd ed., CRC Press.	2020
2	Heat Transfer, Cengel and Boles, 2 nd ed., McGraw Hill.	2002
3	Thermal Design and Optimization, A Bejan, G Satsoranis and M Moran, 2 nd ed., Wiley Inderscience.	1996
4	Computational Fluid Dynamics, Versteeg and Malalasekhera, 1 st ed., Longman Scientific & Technical.	2007

Course Name	:	MEMS AND MICRO SYSTEM DESIGN
Course Code	:	MEE1025
Credits	:	4
L T P	:	3-1-0

Course Objectives:

1	To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices.
2	To educate on the rudiments of micro fabrication techniques.
3	To introduce various sensors and actuators.
4	To introduce different materials used in MEMS.

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
1	INTRODUCTION TO MEMS: Origin of Micro-electro-mechanical-systems (MEMS), Intrinsic characteristics of MEMS and their applications, scaling laws in miniaturization, Materials for MEMS, the multidisciplinary nature of micro-systems.	8
2	MICROMACHINING TECHNOLOGIES: Additive techniques, Oxidation & physical vapor deposition, Chemical vapor deposition, and other additive techniques.	6
3	MECHANICS AND DESIGN OF MICRO-SYSTEMS: Mechanics, Dynamics, electrostatics, Advanced MEMS operating, Principles for sensing and actuation including Piezo resistive, Piezoelectric, Thermo-mechanical, Magnetic, <i>Micro-fluidics:</i> Flow, heat and mass transfer at small scales, Electro kinetics.	8
4	WORKING PRINCIPLE OF MICROSYSTEMS: Micro-sensors, acoustic wave sensors, biomedical and nano-sensors, chemical sensors, optical sensors, pressure sensors, thermal sensors, micro-actuation through thermal forces, SMA-Piezo electric crystals, and electrostatic forces, magnetic actuation, <i>Micro devices:</i> Micro-grippers, Micro-motors, Micro-valves, Micro pumps, Micro-accelerometers.	8
5	POLYMER MEMS: Polymers in MEMS, Polyimide, SU-8, Liquid Crystal Polymer (LCP), PDMS, PMMA, Parylene, Fluorocarbon, Application to Acceleration, Pressure, Flow and Tactile sensors.	6
6	CASE STUDIES OF MEMS PRODUCTS: Micro-fluidic devices, Micro/nano transducers, Blood pressure sensor, Microphone-acceleration sensors, Gyroscope, Magnetic actuation.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Review the fundamentals of MEMS.	L1

2	Apply the basics of electro-magnetic fabrication techniques in mechanical engineering	L3
3	Analyze the mechanics and design of micro-systems.	L4
4	Understand the working principle of MEMS sensors and actuators.	L2
5	Choose the basic devices and techniques to be used in polymer MEMS.	L5
6	Prepare the case studies on MEMS for different industrial applications.	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1	1	-	-	-	-	-	-	-	1	3	1
CO2	1	2	2	1	-	-	-	-	-	-	-	1	2	1
CO3	2	3	3	1	-	-	-	-	-	-	-	1	2	1
CO4	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO5	2	3	2	3	-	-	-	-	-	-	-	1	3	2
CO6	1	1	2	3	-	-	-	-	2	2	-	1	3	1

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Foundation of MEMS, C Liu, Pearson Education.	2017
2	Micro sensors, MEMS and Smart devices, JW Gardner, VK Varadhan, John Wiley & Sons.	2001
3	Nano structure and Nano materials, synthesis, properties and applications, G Cao, Ying, World Scientific Publishing Co.	2011
4	MEMS and Micro system Design and Manufacturing, T R Hsu, Tata McGraw Hill.	2017
5	Nano Scale Science and Technology, Robert K, Ian W H, Mark Geoghegan.	2005

Course Name	:	TRIBOLOGY AND LUBRICATION
Course Code	:	MEE1026
Credits	:	4
L T P	:	3-1-0

Course Objectives: This course is aimed to

1	Give exposure to the students about the interaction between the three basic areas of engineering, i.e., friction, wear and lubrication.
2	Give exposure to complete range of industrial lubricants and their mechanical behavior.
3	Enable students to design sliding contact and rolling contact bearings.

Total No. of Lectures – 42

Sr. No.	Contents	
1	SURFACE INTERACTION AND FRICTION: Topography of surfaces, <i>Surface features</i> : properties and measurement, surface interaction, adhesive theory of sliding friction, rolling friction, friction properties of metallic and non-metallic materials, friction in extreme conditions, thermal considerations in sliding contact, concept on geometry for the performance analysis of bearing.	7
2	WEAR AND SURFACE TREATMENT: Types of wears, mechanism of various types of wear, laws of wear, theoretical wear models, wear of metals and non-metals, plastics and ceramics, surface treatments, surface modifications, surface topography measurements, laser methods, instrumentation, international standards in friction and wear measurements.	7

3	LUBRICANTS AND LUBRICATION REGIMES: Lubricants and their physical properties, viscosity and other properties of oils, additives and selection of lubricants, <i>Lubricants Standards:</i> ISO, SAE, AGMA, BIS standards, lubrication regimes, solid lubrication, dry and marginally lubricated contacts, boundary lubrication.	7
4	SELECTION OF BEARINGS: Selection criteria, dry and boundary lubrication bearings, hydrostatic and hydrodynamic bearings, electromagnetic bearings, dry bearings, rolling element bearings, bearings for precision applications, foil bearings, special bearings, selection of plain bearing materials, metallic and non-metallic bearings, tolerance on bearings.	6
5	THEORY OF HYDROSTATIC AND HYDRODYNAMIC LUBRICATION: Reynolds equation, assumptions and limitations, one- and two-dimensional Reynolds equation, Somerfield boundary conditions, pressure wave, flow, load capacity and friction calculations in hydrodynamic bearings, long and short bearings, pad bearings and journal bearings, squeeze film effects, thermal considerations, hydrostatic bearings & lubrication, design of foil bearings, air bearings.	8
6	HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION: Rolling contacts of elastic solids, contact stresses, Hertzian stress, spherical and cylindrical contacts, contact fatigue life, oil film effects, <i>Elasto Hydrodynamic Lubrication:</i> Theory of soft and hard elasto hydrodynamic lubrication, Reynolds equation for elasto hydrodynamic lubrication, film shape within and outside contact zones, film thickness and friction calculation, rolling bearings, stresses and deflections, traction drives, internal clearance, shaft and housing fit, mounting arrangements, materials for rolling bearings, manufacturing methods, ceramic bearings, rolling bearing cages bearing seals selection.	7

Sr. No.	Course outcomes: By the end of this course, the student will be able to	Knowledge Level (Blooms Level)
1	Recall and understand the basics of friction, wear and lubrication	L1, L2
2	Apply and evaluate wear mechanism principles to different kinds of materials.	L3, L5
3	Analyze the mechanical behavior of lubricants while working between rubbing surfaces under load without causing wear.	L4
4	Selection & design of Journal, Ball and Roller Bearings for different applications.	L6
5	Recall the various equations of fluid mechanics and conjecture these with hydrodynamic lubrication.	L1, L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Friction and Wear of Materials, E. Rabinowicz, John Wiley & Sons, UK.	1995
2	Basic Lubrication Theory, A. Cameron, Ellis Herward Ltd., UK.	1981
3	Principles of Tribology, J. Halling, Macmillan.	1984
4	Engineering Tribology, J. A. Williams, Oxford Univ. Press.	1994

5	Fundamentals of Tribology, S. K. Basu, S. N. Sengupta & B. B. Ahuja, Prentice-Hall of India Pvt. Ltd., New Delhi.	2005
6	Engineering Tribology, G. W. Stachowiak & A.W. Batchelor, Butterworth-Heinemann, UK.	2005
7	Tribology Hand Book, M.J. Neale, Butterworth Heinemann, UK.	2001
8	Tribology and Surface Engineering, Aleksander Lisiecki, MDPI AG	2020

Department Elective Courses IV

Course Name	:	VEHICLE DYNAMICS
Course Code	:	MEE1029
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To understand the basic principles used in dynamic analysis of vehicles.
2	To gain the basic knowledge in the field of vehicle vibrations.
3	To understand the stability of vehicles and their effects related to longitudinal, vertical & lateral dynamics.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	BASICS OF MODELING: Introduction to Vehicle dynamics, Fundamental approach of Modeling, lumped mass, Euler Angles, Vehicle fixed and Earth fixed coordinate systems, motion variables, Newton's second law, Dynamic axle load, static loads on level ground, Role of inertia, Road modeling.	6
2	TYRE DYNAMICS: Tyre forces and moments, Tyre structure, Size and Load Rating, Terminology and Axis System, Tractive and cornering property of tyre, Camber Thrust, Castor, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Performance of tyre on wet surface, Ride property of tyres, Magic formulae tyre model, Estimation of tyre road friction, Test on Various Road surfaces, Tyre vibration and chattering.	6
3	VEHICLE VIBRATIONS: Measures of Ride quality, predictions of vibrations, suspension stiffness and damping, road roughness models, response to speed breakers, Heave, pitch and roll phenomenon of dynamic motion, quarter, half and full vehicle model, Seat suspension, relation to human body vibrations.	6
4	SUSPENSIONS: Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, <i>Controllable Suspension Elements:</i> Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and aft directions.	6
5	STEERING SYSTEM: Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady state model), Under and Over-steer, Effect of Tyre Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3 DOF unsteady model), Steady-State and Transient Handling of Articulated Vehicles.	6
6	LONGITUDINAL DYNAMICS: <i>Dynamic wheel loads:</i> Simple vehicle model, influence of grade, Aerodynamic Forces and Moments, Resistance, Rolling Resistance, Load Distribution for Three-Wheeler and Four-Wheeler, Calculation of Maximum Acceleration, Reaction Forces for Different Drives, Braking and Driving Torque, Prediction of Vehicle Performance.	6
7	LATERAL DYNAMICS: Steady State Handling Characteristics, Steady State Response to Steering Input, Testing of Handling Characteristics, Transient Response Characteristics, Direction Control of Vehicles Roll Center, Roll Axis, Vehicle Under Side Forces, Stability of Vehicle Running on Slope, Banked Road and During Turn, Effect of Suspension on Cornering, Latest Trends in Vehicle Dynamic Testing Like Four Poster, Multi Axis Simulator.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall the basic concept of vibrations and automobile.	L1
2	Understand the vehicle dynamics and apply the vibration concepts when the vehicle is in dynamic condition.	L2 & L3
3	Analyze the tyre dynamics with respect to force & moments.	L4
4	Evaluate the effective steering geometry, vehicle handling and directional control of vehicle.	L5
5	Develop the aerodynamic forces & moments, load distribution in the different vehicles.	L6
6	Ability to model and simulate the vehicle using MATLAB and ANSYS software to analyze the vehicle dynamics.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	2	-	-	-	-	-	-	-	1	3	1
CO3	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO4	3	3	3	3	-	-	-	-	-	-	-	1	3	1
CO5	3	3	3	3	-	-	-	-	-	-	-	-	3	1
CO6	2	2	2	3	3	-	-	-	2	2	-	1	2	2

List of experiments	No. of Turns
The experiment work in this course is intended to be carried out to simulate and study a quarter, half and full vehicle models, behavior of sprung / un-sprung mass & lumped mass system and the effect of different conditions on vehicle loading using MATLAB and ANSYS software in the CAD Lab. In addition, study of latest technologies available nowadays in vehicles helping to maintain stability of the vehicle on the road.	14

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fundamentals of Vehicle Dynamics, Thomas D. Gillespie, Society of Automotive Engineers Inc.	1992
2	Theory of Ground Vehicles, Wong, J. Y., 3 rd ed., Wiley-Interscience.	2001
3	Vehicle Dynamics and Control, Rajesh Rajamani, 1 st ed., Springer.	2005
4	Vehicle Stability, Dean Karnopp, 1 st ed., Marcel Dekker.	2004
5	Vehicle Dynamics: Theory and Application, Nakhai Jazar, G., 1 st ed., Springer.	2008
6	Tyre and Vehicle Dynamics, Hans B Pacejka, 2 nd ed., SAE International.	2012
7	Fundamentals of Vehicle Dynamics, Thomas D. Gillespie, SAE International	2021

Course Name	:	ADVANCED MANUFACTURING TECHNIQUES
Course Code	:	MEE1030
Credits	:	4
L T P	:	3-1-0
Course Objectives: To impart the knowledge of		
1.	Surface modification, PVD, CVD, cladding, diffusion and diamond coating.	
2.	Rapid prototyping, hybrid and micro machining.	
3.	Advance mechanical, thermal, chemical and electrochemical non-conventional machining.	
5.	Advance finishing process and fabrication of microelectronic devices.	

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Trends in modern manufacturing, Classification of advanced manufacturing, <i>Surface modification:</i> Advanced ceramic and organic methods, cleaners, Electro forming, physical and chemical vapour deposition, thermal spraying, ion implantation, diffusion coating, diamond coating and cladding.	6
2	NON-TRADITIONAL MACHINING: <i>Mechanical methods:</i> USM, AJM, AWJM processes: Principle, process parameters, description, mechanics of material removal rate, effect of parameters on machining responses, capabilities, limitations and applications; <i>Chemical and electrochemical methods:</i> Fundamental and mechanics of material removal; CH, ECM, ECG, Electrochemical deburring, Electrochemical honing processes: description, material removal rate, effect of process parameters on performance characteristics, capabilities, limitations and applications; <i>Thermal methods:</i> EDM, WEDM, LBM, EBM, PAM, PAW processes: Principles, mechanics of material removal rate, equipment, analysis of circuits, performance characterization, effect of process parameters on MRR and surface finish, capabilities, limitations and applications.	10
3	HYBRID AND MICRO MACHINING: <i>Hybrid machining:</i> Concept, Classification. ECDSM, TWECDSM, LAECDSM, VAEDM, EDG, Process description, performance characterization, parametric effect, capabilities, limitations and applications; <i>Micromachining:</i> Introduction to micro machining, micro-turning, micro-milling, micro-drilling, micro EDM, micro-WEDM, micro-ECM: Process parameters, MRR, performance characterization, parametric effect, capabilities, limitations and applications.	8
5	RAPID PROTOTYPING: Importance and Types, Principles and advantages, Stereo lithography, FDM, SLS, factors effecting the responses of RP, Accuracy and Economic considerations.	5
6	ADVANCE FINISHING PROCESS: AFM, MRF, MRAFF, MFP, EEM, CMP: Process description, mechanics of finishing, performance characterization, parametric effect, capabilities, limitations and applications.	6
7	FABRICATION OF MICROELECTRONIC DEVICES: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in microelectronics, Integrated circuit and surface mount technology, E-Manufacturing, nanotechnology and MEMS.	7

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Recall previously learnt basic concept of manufacturing and trends in modern Manufacturing.	L1
2	Understand the philosophies of advanced and modern manufacturing.	L2
3	Plan and apply the concept of non-traditional and hybrid machining.	L3
4	Analyze the effects of various process parameters on process performance characteristics.	L4
5	Ability to decide the appropriate manufacturing processes for quality finishing in nano domain.	L5
6	Adapt e-manufacturing, nanotechnology and MEMS for fabrication of microelectronic devices.	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	-	-	-	-	-	-	1	2	2	3
CO2	3	2	3	1	2	-	-	-	-	-	1	2	3	1
CO3	3	3	3	2	2	-	-	-	-	-	2	3	3	2
CO4	2	3	1	3	1	-	-	-	-	-	1	2	2	1
CO5	2	2	3	3	3	-	-	-	-	-	2	1	3	1
CO6	1	1	1	2	3	-	-	-	-	-	1	1	2	2

	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Manufacturing Engineering and Technology, Kalpakjian, Adisson Wesley	1995
	Manufacturing Engineering and Technology, 7 th Ed. Serope Kalpakjia, Steven R. Schmid, Pearson Education.	2018
2.	Process and Materials of Manufacturing, R. A. Lindburg, 4th edition, PHI	1990
3.	Foundation of MEMS, Chang Liu, Pearson publications.	2012
4.	Advanced Machining Processes, V.K.Jain, Allied Publications	2009
5.	Introduction to Manufacturing Processes, John A Schey, Mc Graw Hill	2012

Course Name	:	SURFACE ENGINEERING
Course Code	:	MEE1031
Credits	:	4
L T P	:	3 0 2

Course Objectives:	
1	To impart the knowledge of Surface properties and their impact on performance of components.
2	To get familiar with the various techniques of surface treatment and characterizations of metallic components.
3	To acquire the knowledge of various fields of applications for implementing the surface engineering to improve the product performance.

Total No. of Lectures – 42

Lecture wise breakup	No. of Lectures
1	INTRODUCTION: Importance and necessity of surface engineering; past, present and future scenario of surface engineering; <i>Properties of Solid Surfaces:</i> Tribological and optical properties; Electric and opto-electronic properties, Importance and objectives of surface properties, Corrosion of solid surfaces, Surface preparation techniques. 5
2	WEAR AND CORROSION: <i>Wear:</i> Classification, Abrasive, Solid particle erosion, Liquid erosion, Slurry erosion and adhesive wear; Fretting, Rolling-contact wear, wear measurement; <i>Corrosion:</i> Types and conditions of corrosion, Electrochemical, Uniform, Galvanic, Crevice, Inter-granular, Fretting and Erosion corrosions; Pitting, Cavitation, Exfoliation, Stress-corrosion cracking, Corrosion fatigue, Hydrogen embrittlement, corrosion measurement. 8
3	SURFACE TREATMENT TECHNIQUES: Selective surface hardening, Flame hardening, Induction hardening, High-energy beam hardening, Laser melting and curing, Shot peening, Friction stir processing; Chemical conversion treatment, Diffusion heat treatment of surfaces, Carburizing, Nitriding, powder bed chemical 10

	case hardening.	
4	THIN FILM COATING: Organic and inorganic paintings, Ceramic coatings and linings, Hot dip and electrochemical deposition, Thermal spray and vapour deposition, Powder mixed electric discharge alloying and film deposition, Ion implantation and metal alloying by laser beam.	7
5	CHARACTERIZATION OF ENGINEERED SURFACES: Characterization of surface properties, Thickness of coatings and films, Bond strength of coating, Substrate, Micro-hardness, Phase determination using X-Ray Diffraction (XRD) analysis, Scanning Electron Microscopy (SEM), Metallographic examination.	7
6	APPLICATIONS OF SURFACE ENGINEERING: Surface engineering for cutting tools, automotive engine components, Gas turbine engines, Bio-Medical implants and aerospace industry.	5

Sr. No.	List of Experiments	No. of Turns
1	Wear and corrosion analysis of treated surface.	3
2	Thermal spray deposition of metal powder on surface of cylindrical work-piece.	3
3	Powder mixed EDM operation for surface alloying and analyzing the characteristics of machined surfaces.	4
4	A case study and project work on mechanical treatment and surface modification of metal components.	4

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand the basic surface properties and their importance towards the performance of components and overall economics.	L2
2	Interpret various types of wear and corrosion phenomenon occurring on different types of materials.	L4
3	Understand the facts and ideas on different types of surface modification and coating techniques used in various fields of engineering.	L2
4	Evaluate the surface texture and quality of surface modified by different applied surface treatment techniques.	L5
5	Apply surface modification techniques to modify the surface properties of metallic components.	L3
6	Design surface modification technique for better quality of surface	L6

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	-	-	-	-	-	-	-	1	3	1
CO3	3	2	3	2	-	-	2	-	-	-	-	2	3	1
CO4	3	3	3	3	-	-	-	-	-	-	1	2	3	2
CO5	2	3	3	2	-	-	2	-	-	-	1	2	3	3
CO6	3	3	3	1	-						1	2	3	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Introduction to Surface Engineering and Functionally Engineered Materials, Peter M. Martin, Wiley & Sons Publishing.	2011
2	Coating Technology Handbook, Arthur A. Tracton, 3 rd Edition, Taylor & Francis.	2006

3	Surface engineering for Corrosion and Wear Resistance, J.R. Davis & Associates, ASM International.	2001
4	Modern Surface Engineering Treatments, Mahmood metAliofkhazraei, Intechopen.com.	2013
5	Tribology and Surface Engineering for Industrial Applications, Amit Aherwar, Catalin I. Pruncu, Stanislav Gorb, CRC Press	2021

Course Name	:	PRODUCT DESIGN AND DEVELOPMENT
Course Code	:	MEE1032
Credits	:	4
L T P	:	3-1-0

Course Objectives: At the end of the course, the student will be able to:	
1	Understand the reverse engineering, redesign methodologies and theories.
2	Identify the significance of analytical and numerical techniques in product development engineering.
3	Understand about the physical models and concepts of product design theory.
4	Understand the principles in product development taking care with social, environmental and ethical concerns.

Total No. of Lectures –42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Modern Product Development and Design Theories: Understanding the opportunity, Development and Implementation of a concept, Reverse engineering and redesign methodologies.	4
2	PRODUCT DESIGN PROCESS: Need, Identification, Kano diagram, Establishing Engineering Characteristics, Quality Function Deployment (QFD), Product Design Specification (PDS), Information Gathering.	8
3	CONCEPT GENERATION: Creative methods for design, Functional decomposition and synthesis, Morphological methods, Theory of Inventive Problem solving, Axiomatic Design.	10
4	CONCEPT EVALUATION AND DECISION MAKING: Concept evaluation and decision making: Decision Theory, Evaluation methods, Pugh's concept, weighted decision Matrix.	8
5	EMBODIMENT DESIGN: Product Architecture, Configuration and Parametric Design Concepts, Ergonomics and Design for Environment and detailed design.	6
6	ETHICAL ISSUE AND TEAM MANAGEMENT: Ethical issues considered during Engineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem solving tools in design, Case studies.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understanding the principle and theories of Product Design and Development.	L2
2	Apply the concept of creative methods for generation and development of product.	L3
3	Analyze the engineering characteristics and quality function deployment for gathering the information to develop new product.	L4
4	Design the product architecture and configuration of new product.	L6

5	Develop Ergonomics and consciousness for environmentally sustainable manufacturing and product.	L6
6	Judge and evaluate the methods and decision metrics to develop the product.	L5

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	-	-	-	-	-	-	-	1	2	1
CO2	3	3	3	1	-	-	-	-	-	-	1	2	3	2
CO3	3	3	2	2	1	-	-	-	-	-	-	2	3	1
CO4	3	3	3	3	2	-	-	-	-	-	1	2	3	2
CO5	3	3	3	2	-	-	-	-	-	-	1	2	3	3
CO6	3	3	3	3	-	-	-	-	-	-	-	1	3	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Design, George E Dieter, 3 rd ed., McGraw Hill	2012
2	Product Design Kevin N. Otto, Kristin L. Wood, Pearson Education	2004
3	Engineering Design, Gahl, W Beitz J Feldhusun, K. G. Grote, 3 rd ed., Springer.	2007
4	Introduction to Design Engineering, W. Ernest Eder, S. Hosendl., CRC Press.	2017
5	Engineering Design and Rapid Prototyping, Ali K. Kamrani and EmadAbouel Nasr, Springer.	2010

Course Name	:	COMPOSITE MATERIALS
Course Code	:	MEE1022
Credits	:	4
L T P	:	3-0-2

Course Objectives: To impart the knowledge about the

1. Matrix, interfaces, fibers, whiskers being used in fabrication of composites.
2. Polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon-carbon composites and their manufacturing.
3. Testing, properties and applications of different composite materials.
4. Post processing and micromechanics of composites.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	Composite: Definition, characteristics, functions, classification based on structure and matrix, smart composites, advantages and limitations, industrial scene and applications, Interfaces: wettability and bonding interface in composites, types of bonding at interface. Fibers: types, natural, glass, boron, carbon, Ex-Pan carbon, Ex cellulose carbon, Ex-Pitch carbon, and aramid fibers, fiber structure, properties, applications, and recycling; Whiskers: characteristics, properties and applications.	7
2	Polymer matrix composites (PMC): Thermoset, thermoplastic and elastomeric polymers, properties, characteristics and applications as matrix materials, processing of polymer matrix composites: hand methods, Lay up method, spray up method, moulding methods, pressure bagging and bag moulding methods, pultrusion and filament winding process.	6

3	Metal matrix composites (MMC): Classification of metals, inter-metallic's, alloys and their potential role as matrices in composites; properties, characteristics and applications of MMCs, production techniques: powder metallurgy, diffusion bonding, melt stirring, squeeze casting, liquid infiltration under pressure, spray code position, in-situ process.	6
4	Ceramic matrix composites (CMC): Classification of ceramics and their potential role as matrices; properties, characteristics and applications of CMC; <i>Production techniques:</i> cold pressing and sintering, hot pressing, reaction bonding, hot pressing and reaction bonding, liquid infiltration, pultrusion, lanxide process, in-situ chemical technique, sol-gel technique, <i>Post processing of CMC:</i> machining, cutting, polishing, welding, riveting, painting, and plasma coating.	7
5	Carbon Carbon Composites (CCC): Classification of carbon and their potential role as matrices; Production techniques of CCC; Properties, characteristics and applications of CCC.	4
6	Testing of Composites: Mechanical testing of composites, tensile and compressive testing, Intra-laminar and Inter-laminar shear testing, Fracture testing; <i>Stiffness and Strength:</i> Geometrical aspects-volume and weight fraction. Effect of unidirectional continuous fiber, discontinuous fibers, short fiber, woven reinforcements on mechanical properties.	5
7	Laminates: Types, Symmetric Laminates, Anti-symmetric Laminate, Balanced Laminate, Quasi-isotropic Laminates, Cross-ply Laminate, Angle-ply Laminate. Orthotropic Laminate, Volume and Mass Fractions, Density and Void Content, Laminate Moduli, Approaches and Models of Four Elastic Moduli, Hygrothermal Stresses. Strengths of unidirectional Lamina, Coefficients of thermal, moisture expansion and Warpage of laminates.	7

Sr. No.	List of Experiments	No. of Turns
1	Fabrication of Al/SiC-MMC specimen	3
2	Fabrication of PMC by Layup method	3
3	Fabricate and prepare the MMC specimens as per standard size, perform tensile and compressive tests, and analyze the test results	4
4	A project work on machining and joining of CMC materials	4

No.	By the end of this course, the student will be able to:	(Blooms Level)
1	Understand the mechanical behavior of layered composites compared to isotropic materials.	L2
2	Design and develop the process to fabricate different types of composites materials.	L6
3	Evaluate the mechanical properties and strength of composite materials.	L5
4	Select and apply the process to develop composites, and apply constitutive equations to acquire the knowledge mechanical behavior at micro, macro and meso level.	L3
5	Analyze the mechanical behavior of composites due to variation in temperature and moisture.	L4

CO-PO & PSO course Articulation Matrix

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

CO5	3	3	1	2	-	-	-	-	-	-	-	2	3	1
-----	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Composite Materials: Science and Engineering, K. K. Chawla, Springer, 3e,	2013
2	Composite Materials, Engineering and Sciences, F.L.Matthews & R.D.Rawlings, Chapman & hall, London,	1994
3	Hand Book of Composites, George Lubin. Van Nostrand, Reinhold Co.	1982
4	Fiber-reinforced composites, P.K.Mallicak, Monal Deklar Inc., New York, 1988	1988
5	Principles of Composite Mechanics, R.F. Gibson, 2nd Ed., CRC Press.	2007
6	Introduction to Composite Materials Design 3rd Edition, Ever J. Barbero, CRC Press	2017

Course Name	:	TWO-PHASE FLOW HEAT TRANSFER
Course Code	:	MEE1033
Credits	:	4
L T P	:	3-1-0

Course Objectives:

1	To understand the phenomena occurring at micro and nano scale.
2	To understand the basic mechanisms involved in two phase flow and heat transfer.
3	To understand the concepts of pool boiling and flow boiling heat transfer
4	To introduce the film wise and drop wise mode of condensation.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	LIQUID-VAPOR INTERFACIAL REGION: Molecular Perspective on Liquid-Vapor Transitions, Molecular Theories of Capillarity, Nano-scale Features of the Interfacial Region, <i>Interfacial Tension Effects:</i> Determination of Interface Shapes, Effect of Temperature and Surfactant Effects, Near Critical Point Behavior and Effects of Interfacial Tension Gradients.	6
2	WETTING PHENOMENA AND CONTACT ANGLES: Equilibrium Contact Angles, Wettability, Cohesion and Adhesion, Effect of Surface Tension on Contact Angle, Adsorption and Spread Thin Films, Contact-Angle Hysteresis, Wettability of Micro-structured and Nano-structured Surfaces.	5
3	HOMOGENEOUS NUCLEATION: Thermodynamic Aspects of Homogeneous Nucleation in Superheated and Super-cooled Liquids, Kinetic Limit of Superheat and Super-saturation, Effect of Wall Interaction.	4
4	HETEROGENEOUS NUCLEATION AND BUBBLE GROWTH: Heterogeneous Nucleation at a Smooth Interface, Nucleation from Entrapped Gas or Vapor in Cavities, Criteria for the Onset of Nucleate Boiling, Bubble Growth in an Extensive Liquid Pool, Bubble Growth Near Heated Surfaces, Bubble Departure Diameter and Frequency of Bubble Release.	5
5	POOL BOILING: Regimes of Pool Boiling, Mechanisms and Models of Transport during Nucleate Boiling, Correlation of Nucleate Boiling Heat Transfer Data, Limitations of Nucleate Boiling Processes and the Maximum Heat Flux Transition, Minimum Heat Flux Conditions, Film Boiling, Transition Boiling, Leiden frost Phenomenon, Fluid-Wall Interactions and Disjoining Pressure Effects and Pool Boiling Heat Transfer on Micro and Nano Structured Surfaces.	7

6	TWO-PHASE FLOW REGIMES: Basic Models and Governing Equations for One-Dimensional Two-Phase Flows, Determination of the Two-Phase Multiplier and Void Fraction, Analytical Models of Annular Flow, Effects of Flow Passage Size and Geometry.	7
7	FLOW BOILING: Regimes of Convective Boiling in Conventional (Macro) Tubes, Onset of Boiling in Internal Flows, Sub-cooled Flow Boiling, Saturated Flow Boiling, Critical Heat Flux Conditions, Post-CHF Internal Flow Boiling, Flow Boiling in Micro-Channels.	4
8	CONDENSATION: <i>Nusselt theory:</i> Importance, Limitations and Modifications, Film Condensation on a Flat Vertical Surface, Effects of Vapor Motion, Interfacial Waves and Non-condensable Gases, Heterogeneous Nucleation in Vapors, <i>Drop wise Condensation:</i> Surface Requirements, Fundamentals and Recent Advancements.	4

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Identify the important forces and their characteristics at small scale.	L2
2	Apply the basics of two-phase heat transfer processes on simple and complex systems.	L3
3	Examine the performance of two-phase heat transfer systems.	L4
4	Select the suitable phase-change heat transfer process and evaluate the important process parameters for practical applications.	L5
5	Design heat transport systems for boiling and condensation heat transfer.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Liquid-Vapor Phase-Change Phenomena: An Introduction to the Thermo physics of Vaporization and Condensation Processes in Heat Transfer Equipment, Van P. Carey, 3 rd Edition, CRC Press.	2020
2	Convective Boiling and Condensation, J.G. Collier, Clarendon Press.	1996
3	Boiling Heat Transfer and Two-phase Flow, L. S. Tong, and Y.S. Tang, 1 st ed., Rutledge.	2018
4	Encyclopedia of Two-phase Heat Transfer and Flow, John R Thome, A 4-volume Set, World Scientific.	2018

Course Name	:	THERMAL SYSTEM MODELING AND SIMULATION
Course Code	:	MEE1034/MEM1002
Credits	:	4
L T P	:	3-1/2-2/2

Course Objectives:	
1	To understand the significance of modelling and simulation of different engineering problems using various techniques.
2	To understand various mathematical techniques in solution of variety of problems related to design and optimization of Thermal Systems.
3	To understand the application of software for modelling, simulation and optimization of engineering systems problems.
4	To design and analyze of industrial equipment's and hydraulic systems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION TO THERMAL DESIGN: Design, Mathematical Modelling and Numerical Simulation of Thermal Systems, Approach to Robust Design, Numerical Methods for thermal and energy systems, Closed form solutions of heat transfer problems, Finite Difference and Finite Volume Formulations, TDMA Method	07
2	DESIGN AND ANALYSIS OF THERMAL EQUIPMENT: Design Strategies, Design of Heat Exchanger, Refrigeration System, Solar Thermal System, Heat Pump, Cooling of Electronic Components, Energy Storage System and Design Consideration for Engineering Material Selection.	07
3	DESIGN AND ANALYSIS OF HYDRAULIC SYSTEM: Introduction to Hydraulic Systems, Constituents of Hydraulic System, Directional Control Valve, Pressure Control Valve and Flow Control Valve, Hydraulic Circuit Design and Analysis.	07
4	OPTIMIZATION: Basic Concepts, Objective Function, Methods, Optimization of Mechanical System and case studies, Practical Aspects in Optimal Design, Constrained and Unconstrained Problems: Langrage Multiplier, Geometric & Dynamic Programming based optimization.	07
5	THERMAL SYSTEM SIMULATION: Simulation of Periodic Heat Transfer, Laminar and Turbulent Convection, Compressible Flow in Nozzle, Cavitation and Solidification, Flow Past a Cylinder, Flat Plate Boundary Layer.	07
6	ECONOMIC AND EXERGO-ECONOMIC ANALYSIS: Estimation of Total Capital Investment, Principal of Economic Evaluation, Calculation of Revenue Requirements, Levelized Cost Rates, Cost Rate of Exergy Destruction, Exergy Destruction, Percentage Relative Cost Difference, Total Operating Cost Rate and Exergo-economic Factor.	07

Experiments:	No. of Turns
Thermal system modelling and simulation experiments on Heat Exchanger, refrigeration system, hydraulic system, solar energy, energy storage etc. will be performed using ANSYS Fluent /CFX, COMSOL etc.	07

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	To have knowledge of different aspects of designing of a thermal system.	L1, L3
2	To identify and examine a design problem associated to a thermal system.	L4

3	To integrate thermal component models and simulate a thermal system.	L6
4	To design, formulate analysis and solve engineering problems using knowledge of various disciplines.	L7
5	To inculcate an ability to identify, formulates, and solves engineering problems using mathematical techniques.	L2, L5
6	To perform technoeconomic analysis of thermal system using commercial software techniques.	L3
7	To communicate thermal system designs both orally and in writing.	L6
8	To understand some of the ethical and societal issues associated with design and optimization of thermal system.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	-	-	-	-	-	-	-	-	2	1
CO2	2	3	2	1	-	-	-	-	-	-	-	-	2	1
CO3	2	2	1	3	2	1	-	-	-	-	-	-	3	2
CO4	2	3	1	1	3	2	1	-	-	-	-	-	3	2
CO5	3	2	2	1	1	2	1	-	-	-	-	-	1	3
CO6	2	2	3	2	-	-	-	-	-	-	-	-	1	3
CO7	2	2	-	3	-	-	-	-	-	1	2	3	1	3
CO8	3	2	2	3	-	-	-	1	1	1	-	-	1	3

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Design and Optimization of Thermal System with MATLAB Applications, Y Jaluria, 3 rd ed., CRC Press.	2020
2	Heat Transfer, Cengel and Boles, 2 nd ed., McGraw Hill.	2002
3	Thermal Design and Optimization, A Bejan, G. Satsoranis and M Moran, 2 nd ed., Wiley Inder science.	1996
4	Computational Fluid Dynamics, Versteeg and Malalasekhera, 1 st ed., Longman Scientific & Technical.	2007

Course Name	:	NON-CONVENTIONAL ENERGY RESOURCES
Course Code	:	MEE1035
Credits	:	4
L T P	:	3 - 1 - 0

Course Objectives: To understand the

1	Solar energy, wind energy and biomass energy technologies.
2	Basic concepts of solar radiation, solar thermal systems and PV cells.
3	Wind-energy potential and get familiarize with different systems for its effective utilization.
4	Bio-energy generation from the bio-waste and waste management system.

Total No. of Lectures – 42

Lecture wise breakup		No.of Lectures
1	INTRODUCTION: Introduction to sustainable energy, energy and environment, energy scenario and role of renewable in India, human development index, conventional energy sources, limited fossil fuels, environmental impact of fossil fuels, energy alternatives, introduction to various sources of renewable energy.	4
2	SOLAR RADIATION AND ITS MEASUREMENT: Extra-terrestrial radiation, spectral distribution, solar constant, solar radiations on earth, measurement of solar radiations, solar radiation geometry, solar radiation on tilted surface.	4
3	SOLAR ENERGY: Solar flat plate collector, solar air heater, solar water heater, types of concentrating collectors, solar energy tracking systems, introduction to solar thermal energy storage systems, solar energy plants in India, Solar energy mission, environmental impact of solar energy, Solar photovoltaic systems and applications.	6
4	WIND ENERGY: Introduction, Wind resource assessment, wind data and energy estimation, energy pattern factor in wind power, Weibull probability density function, Beaufort wind scale, Wind power generation curve, Fundamentals and classification of wind turbines, aerodynamic design principles, Modern wind turbines and their characteristics, power extraction and control strategies, Modes of wind power generation, Wind energy farms, Wind energy power plants in India, Futuristic hybrid wind-solar system, Economic consideration and environmental impact.	12
5	BIO-ENERGY: Introduction, Photosynthesis, Constituents of biomass materials, <i>Analysis of biomass:</i> Biochemical, Proximate analysis, Ultimate analysis, <i>Primary biomass as source of energy:</i> Woody biomass, oilseed crops, energy plantation, <i>Secondary biomass as source of energy:</i> Residues and wastes, Processes of biomass separation and pelleting, <i>Thermochemical Processing:</i> Combustion, pyrolysis, gasification, hydrothermal processing, transesterification, producer gas, bio-diesel, <i>Biochemical Processing:</i> Anaerobic digestion, fermentation to produce ethanol, enzymatic conversion, <i>Bio-power generation systems:</i> Energy from urban waste, liquid waste, Power generation from landfill gas, biomass cogeneration, biomass resource development in India, environmental impact and future of bio-energy.	12
6	WASTE CYCLE MANAGEMENT: Introduction, Common source of waste, Different types of waste, Waste management, Recycling processes and waste management, Advantages and disadvantages of recycling waste and Recycling plants.	4

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Introduction to energy and environment, energy scenario in India and role of renewable energy.	L2
2	Demonstrate various renewable energy systems based on solar, wind and bio-energy, and discuss their present status and future plans in India.	L3
3	Estimate the solar radiation, formulate heat transfer equations, and analyze modern energy conversion systems used in solar applications.	L4 L5
4	Examine the wind energy potential and evaluate the performance of wind energy plants.	L4 L5
5	Examine different methods of bio-energy sources, bio-energy harvesting, waste cycle management, and evaluate their economic and operational viability.	L4 L5

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Non-Conventional Energy Sources, G.D. Rai, Khanna Publishers, New Delhi	2014
2	Renewable Energy Resources, Twidell, J.W. & Weir, A., EFN Spon Ltd., UK	2005
3	Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K.	2012
4	Solar Energy: Principles of Thermal Collection and Storage, S.P. Sukhatme, Tata McGraw Hill Publishing Company Ltd., New Delhi.	2009
5	Solar Energy – Fundamentals Design, Modelling and applications, G.N. Tiwari, Alpha, Science Intl Ltd.	2015
6	Non-Conventional Energy Resources, B.H. Khan, McGraw Hill	2017
7	Wind Energy Explained-Theory, Design and Applications, J. F. Manwell, J. G. McGowan, and A. L. Rogers, 2 nd ed. Wiley	2010
8	Renewable Energy Resources, J. Twidell and T. Weir, 3 rd ed. Routledge	2015
9	Principles of Sustainable Energy Systems, F. Kreith, 2 nd ed. CRC Press	2014

Course Name	:	EXPERIMENTAL METHODS FOR ENGINEERS
Course Code	:	MEE1036
Credits	:	4
L T P	:	3-1-0

Course Objectives:

1	To understand the measurement terminologies and the concept of measurement system.
2	To find the errors and uncertainty in the measurements.
3	To understand different sensors used for measurement.
4	To identify correct DAQ system for recording and analyzing the experimental results.

Total No. of Lectures – 42

Lecture wise breakup		No of Lectures
1	INTRODUCTION TO EXPERIMENTAL METHODS: Measurement, Instrument, Measurement methods, Generalized measurement system and its functional elements, Classification of instruments, <i>Basic concepts:</i> accuracy, precision, Range, Resolution, Span, Experiment planning, <i>Analysis of experimental data:</i> Error Analysis, Evaluation of and propagation of uncertainties; Regression analysis, Calibration of instruments.	5
2	INSTRUMENT CHARACTERISTICS: Introduction, Static terms and characteristics, Dynamic terms and characteristics, Standard test-inputs, Zero, first and second order instruments, Response of first and second order system.	4

3	FLOW MEASUREMENT AND VISUALIZATION: Positive-displacement methods, Flow-obstruction methods, Sonic nozzle, Flow measurement by drag effects, Pressure probes, Hot-wire and hot-film anemometers, Magnetic flow meters, <i>Flow visualization methods</i> : Smoke methods, Shadowgraph, Schlieren photography, Laser Doppler anemometer, Laser-induced fluorescence, Particle image velocimetry.	10
4	TEMPERATURE MEASUREMENT: Temperature scales, Ideal-gas thermometer, Temperature measurement by mechanical and electrical effects, Temperature measurement by radiation, Transient response of thermal systems, Thermocouple compensation, Temperature measuring problems in flowing fluids, Dynamic compensation, Field temperature measurement using infrared camera.	10
5	TRANSPORT-PROPERTY MEASUREMENT: Measurement of thermal conductivity, Measurement of viscosity, Gas diffusion calorimetry, Convection heat transfer measurement, Humidity measurement, PH measurement, <i>Thermal-radiation measurements</i> : Emissivity measurement, Reflectivity and transmissivity measurement, Air pollution sampling and measurement, Gas sampling techniques, Combustion products measurement.	8
6	DAQ AND SIGNAL ANALYSIS: Systems for data acquisition and processing, Modules and computerized data system, Selection criteria for choosing a DAQ system, Digitization rate, Time and frequency domain representation of signals, Nyquist criterion, Techniques for signal analysis, <i>Signal conditioners</i> : Filters, low, high, band pass and amplifiers.	5

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Discuss different measurement systems and signal recording procedures.	L2
2	Interpret the error and minimize the uncertainty in the experimental data.	L3
3	Employ different measurement devices in real-time system to correctly measure the parameters of interest.	L4
4	Select the suitable DAQ system for recording of the experimental data.	L5
5	Design and implement the experimental measurement methodology to existing and new thermo-mechanical systems.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Experimental Methods for Engineers (SIE), J. P. Holman, 7 th ed., McGraw-Hill.	2017
2	Theory and Design for Mechanical Measurements, R. S. Figliola and D. Beasley, 7 th ed., John Wiley & Sons.	2020
3	Measurement Systems, E. O. Doebelin, 7 th ed., McGraw-Hill.	2019
4	An Introduction to Error Analysis, J. R. Taylor, 2 nd ed., University Science Books.	1997
5	Theory and Design for Mechanical Measurements, Alex. C. Beasley, Intelliz Press.	2017

Course Name	:	MICRO-NANO SCALE HEAT TRANSFER
Course Code	:	MEE1037
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To understand the basic concept of micro/nano scale heat transfer and micro/nano-fluids.
2	To understand the conduction, convection and radiation heat transfer at micro/nano scale.
3	To study the thermal energy storage and transport system.
4	To know the basics of micro-fluidics based devices for micro-flow and biological systems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Micro-Nano Scale Phenomena, Basics of Micro/Nano Scale Heat Transfer and Fluid Mechanics, Miniaturization, Difference between Micro and Macro Scale Heat Transfer Phenomena, Impact of Micro-Nano Technology, Statistical Thermodynamics, Quantum Mechanics, Thermal Properties of Molecules and Kinetic Theory.	7
2	THERMAL TRANSPORT IN SOLID MICRO-NANO STRUCTURES: Electron and Phonon Scattering, Size Effects, Quantum Conductance, Electronic Band Theory, Tunneling, Non-equilibrium Heat Conduction and Analysis of Solid-State Devices like Thermoelectric Refrigeration and Optoelectronics.	7
3	HEAT TRANSFER AT MICRO-NANO SCALE: Fundamentals and Engineering Applications, Methods and Observations of Thermo-Physical Phenomena in Size-Affected Domains, Principal Concepts and Practical Design Engineering, <i>Modern Engineering Applications:</i> Micro-channel Heat Sinks, Micro Heat Exchangers and Micro Heat Pipes. <i>Fundamentals of Nano Scale Thermal Phenomena in Fluids:</i> Nano Scale Thermal Phenomena, Nano-scale Thermal Radiation and Radiative Properties of Nano-materials, Surface Electromagnetic Waves, Problems on Micro-scale Conduction, Convection and Radiation Heat Transfer and Modeling.	10
4	THERMAL ENERGY STORAGE AND TRANSPORT: Storage by Conduction in Natural and Engineered Structures, Thermal Energy in Two Carriers, I.E. Phonons and Electrons, Solid-State Transport, Quantum of Thermal Conductance, Ballistic Interface Resistance and Carrier Scattering, <i>Bulk Material Properties:</i> Thermal and Electrical Conductivity Derived from Particle Transport Theories, Effects of Spatial Confinement on Bulk Properties.	7
5	MICRO-FLUIDICS: Introduction, Important forces and scaling analysis, Governing equations, Fluids flowing in miniaturized systems, <i>Applications:</i> Fluid control devices, gas and fluid measurement devices, medical testing equipments and implantable drug pumps.	5
6	NANO-FLUIDICS: Introduction, Fundamentals of Nano-fluidics, <i>Nano-fluidic Energy Absorption:</i> Converting Mechanical Energy to Thermal Energy, <i>Nano-fluidic Energy Tapping:</i> Temporarily Storing Mechanical Energy, <i>Nano-fluidic Actuation:</i> Converting Thermal/Electrical Energy to Mechanical Energy, <i>Nano-fluidic Energy Harvesting:</i> Converting Thermal/Mechanical Energy to Electrical Energy.	6

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understand the difference among the heat transports phenomena at macro, micro, and nano-scale.	L2
2	Apply the concepts of the thermal energy storage and transport at micro- nano scale systems.	L3
3	Analyze the heat transfer processes occurring by means of conduction, convection and radiation at small scale.	L4

4	Examine heat storage and heat transfer in solids at micro-nano structure levels, and transport behaviour in micro-nano fluidic applications.	L5
5	Evaluate the performance of micro-fluidic and nano-fluidic system, and develop new system.	L5 & L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Micro-scale and nano-scale heat transfer - Fundamentals and engineering applications, C.B. Sobhan, G.P. Peterson, CRC press.	2008
2	Micro-scale heat transfer - Fundamentals and applications in biological and micro-electro-mechanical systems, Editors: S. Kakaç, L.L. Vasiliev, Y. Bayazitoğlu, Y. Yener, Springer.	2004
3	Nano/Micro-scale Heat Transfer, Zhuomin Zhang, McGraw-Hill	2007
4	Thermal Energy at the Nano-scale - Lessons from Nano science, A Lecture Notes Series, Timothy S Fisher.	2013
5	Micro fluidics and Nano fluidics - Theory and Selected Applications, Clement Kleinstreuer, Wiley.	2013
6	Introduction to Micro-fluidics, Patrick Tabeling, Oxford University Press	2010
7	Introduction to Bio-MEMS, Albert Folch, CRC press	2019

Department Elective Courses-V

Course Name	:	PRINCIPLES OF PRODUCT DESIGN
Course Code	:	MEE1038
Credits	:	4
L T P	:	3-1-0

Course Objectives: In this course, the student will be able to	
1	Learn the technologies and practical applications in the product design and development.
2	Learn how to manage a product over whole product lifecycle.
3	Understand the components and their functions in product design and development processes.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	OVERVIEW OF THE DESIGN PROCESS: Philosophy of Engineering Design, Steps involved in the Design Process, S-curves, Challenges of Product Development.	3
2	PROBLEM DEFINITION: Identifying Customer needs and requirements, Establishing Engineering Characteristics, Quality Function Deployment (QFD), Product Design Specification.	6
3	FUNCTIONAL DESIGN: Functions in engineering Design, Basics of Function Structure, Functional analysis and its steps, Functional Basis, Functional decomposition and flow.	7
4	PRODUCT CONCEPT: Methods of concept generation, Theory of resolution of invention-related tasks (TRIZ), Concept selection and methods of evaluation.	8
5	EMBODIMENT DESIGN: Product architecture, configuration, parametric design, systems approach and other consideration, Introduction to product metrics, Product evaluation techniques.	8
6	INDUSTRIAL DESIGN: Aesthetics and ergonomic aspects of product design, Concepts of Value Engineering, Evaluation of function, cost, worth and value, Failure mode and effects analysis.	6
7	LEGAL AND ETHICAL ISSUES IN INDUSTRY: Origin of laws, Contracts, Product Liability, Tort Law, Codes of Ethics and solving ethical conflicts.	4

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand and analyze the product design and development processes.	L2 & L4
2	Apply and evaluate the methodologies for product design, development and management.	L3 & L5
3	Differentiate between embodiment and industrial design.	L4
4	Create and plan a methodical approach to the management of product development to satisfy customer needs.	L6
5	Interpret the legal and ethical issue in product development.	L4

CO-PO & PSO course Articulation Matrix

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

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Design, George E Dieter, 3 rd ed., McGraw Hill.	2001
2	Engineering Design, Pahl, W Beitz J Feldhusun, K G Grote, 3 rd ed., Springer.	2007
3	Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, Tata McGraw Hill.	2007
4	The Mechanical Design Process, David G. Ullman, McGraw Hill.	2017

Course Name	:	INDUSTRIAL ENGINEERING AND MANAGEMENT
Course Code	:	MEE1039
Credits	:	4
L T P	:	3-1-0

Course Objectives: In this course, the student should be able to understand the	
1.	Concept and significance of Industrial engineering & Management and focus on financial management.
2.	Plant location & layout and applications of inventory control systems.
3.	Applications of Time & Motion study and Value Engineering.
4.	Marketing and Strategic Management.

Total No. of Lectures – 42

Lecture wise breakup		No. of lectures
1	INTRODUCTION: Concept, nature and significance of Industrial Management, economic, social, political forces affecting business operations & growth. Social responsibility of business.	4
2	FINANCIAL MANAGEMENT: Scope and functions of financial management, sources of finance, Balance sheets and financial ratios, Capital Budgeting Decisions, Nature of investment decisions, Cost of capital and its measurement, Capital Budgeting process, technique of capital budgeting, Investment criteria: payback period, Accounting rate of return method, Discount cash flow method, Net present value method and internal rate of return method, Management of working capital, factors affecting requirement of working capital, capital structure decisions.	6
3	PRODUCTION MANAGEMENT: Plant location, Weber's Theory of location of industries, Layout and assembly line balancing- process and product layout, Government policies on industrial location, Production control charts, Route & process charts, Operation charts, Machine load charts, Process charts, Mechanical and Bar charts.	6
4	MATERIALS AND STORE CONTROL: Introduction, significance and scope. Materials requirement planning, Inventory control- deterministic and probabilistic models, ABC analysis, EOQ model, LIFO and FIFO in inventory system, Types of purchasing, Centralized and De-centralized purchasing.	6
5	TIME AND MOTION STUDY: Time and motion study, Job design, job standards, work measurement time study, work sampling, job evaluation, merit rating, method studies, pre-determined motion time standards (PMTS).	7
6	VALUE ENGINEERING: Introduction, applications and types of values, concepts of value engineering, phases of value engineering studies, value analysis.	5
7	MARKETING MANAGEMENT: Nature, scope & importance of Marketing management, Modern marketing concepts, Consumer vs Industrial marketing, marketing mix meaning, nature and scope of international marketing, rural marketing, advertising, sales and distribution management, channel management.	4

8	STRATEGIC MANAGEMENT AND NEW TRENDS: Strategic management, industry matrix plus EFAS, IFAS and SFAS tables. DMAIC – Six Sigma.	4
----------	---	----------

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	Understand and illustrate the plant location & layouts concepts of the manufacturing plant	L2
2	Apply the concepts of Industrial and Financial Management in industries.	L3
3	Analyze the process involved in various inventory models in industries.	L4
4	Explain and evaluate the Time and motion study concepts in the design the workplace layout design.	L5
5	Apply the concepts of Value engineering and Value analysis.	L3
6	Analyze the principles of Marketing & Strategic management.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	1	1	1	1	-	-	-	1	-	1	1
CO2	2	1	1	1	3	-	2	-	-	-	1	-	1	1
CO3	2	1	1	-	2	-	2	-	1	-	1	-	1	2
CO4	2	1	1	2	2	-	2	-	1	-	-	-	1	1
CO5	2	1	1	1	2	1	2	-	1	-	-	-	1	1
CO6	1	2	1	-	3	-	1	-	-	1	3	-	1	2

	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Industrial Engineering and Management, Hicks, Tata McGraw Hill, New Delhi	2003
2.	Industrial Management, W.R. Spreigel, 4 th ed., John Wiley & Sons: NY	1947
3.	Financial Management, Pandey, Vikas Publishing House, New Delhi	2016
4.	Estimating and Costing for Metal Manufacturing Industries, Creese, Adihan and Pabla, Marcel Dekker Inc., New York	1992
5.	Motion and Time Study, R. Barnes, John Wiley & Sons.	2017

Course Name	:	RELIABILITY AND MAINTENANCE ENGINEERING
Course Code	:	MEE1040
Credits	:	4
L T P	:	3-1-0

Course Objectives: To impart the knowledge
<ol style="list-style-type: none"> 1. On the role and contribution of maintenance towards achieving competitive advantage in the industries. 2. About the key concepts and issues of maintenance in both manufacturing and service organization. 3. About the various strategies, philosophy, scheme and schedules of maintenance engineering and its applications in the industry. 4. About the safety, housekeeping, breakdown, availability and reliability indices of engineering system.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION: Concept, classification and types of maintenance, preventive, corrective, renovative, planned, breakdown and quality maintenance; objectives and characteristics of maintenance function, organizational set-up and record keeping, Organizational hierarchy, position and responsibilities of maintenance department, control and coordination in maintenance, benefits and effects of maintenance.	6
2	MAINTENANCE PLANNING AND SPARE PARTS MANAGEMENT: Long and short term planning and scheduling; man power planning, training and allocation, requirement planning of raw materials and spare parts, inventory control of spare parts, ABC analysis, FSN Approach, XYZ approach, VED approach, Estimation of maintenance work and monitoring.	5
3	HOUSEKEEPING AND SAFETY IN MAINTENANCE: Factors governing housekeeping, illumination, layout and equipment, air distribution, pollution and ventilation, training and awareness in housekeeping; <i>Safety:</i> Classification and types of hazards, important factors and measurement of hazards, minimize hazards and control of accidents, fault tree analysis, safety devices and check list.	5
4	RELIABILITY AND AVAILABILITY OF ENGINEERING SYSTEMS: Reliability and maintainability, failure, Bathtub hazard rate concept; <i>Reliability structures:</i> series, parallel, combination of series and parallel, redundancy; Quantitative estimation of reliability of parts, mean time to failure (MTTF), mean time between failure (MTBF), mean time to repair (MTTR), accuracy and confidence of reliability estimation, statistical estimation of reliability indices, machine failure pattern: breakdown time distribution, machine failure pattern.	6
5	MAINTENANCE OF DRIVES AND EQUIPMENTS: <i>Mechanical drives and equipment's:</i> belts, chains, gears, couplings, brakes and their drives; pumps, compressors, blowers, air-conditioners; <i>Electrical circuits and equipment's:</i> power cable, line and circuit connection, switchboard, fuse, relays, interlocks, contactors, measuring equipment's, motors, generators; essential care and maintenance; <i>Lubrication:</i> manual, forced and oil bath lubrication, testing, additives used, rectification and re-use of lubricants; <i>Corrosion:</i> factors influencing and effect of pH value on corrosion, testing, prevention, application of inhibitors and control techniques	5
6	INSPECTION, TESTING, QUALITY CONTROL AND AUDIT IN MAINTENANCE: <i>Inspection:</i> objectives, interval, card history and report; <i>Testing:</i> non-destructive, destructive and semi-destructive testing; liquid penetration test, magnetic particle test, ultrasound test, vibration analysis, oil analysis, eddy current testing; <i>Quality Control:</i> importance, application of statistical quality control tools and techniques; <i>Performance and audit:</i> Maintenance performance indices-BPI, EQBI, MEI, BAI, MUI, EURRI, BEI; function and operational audit, plan and programme audit.	5
7	FAULT DIAGNOSIS AND CONDITION MONITORING: Objectives, methods and purpose of faults diagnosis and condition monitoring, non-vibration and vibration-based monitoring; periodic and continuous monitoring methods and equipment's used; fault diagnosis and condition monitoring of bearings; computerized trouble shooting and condition Monitoring;	5
8	BUDGET AND COST ESTIMATION OF MAINTENANCE: <i>Cost estimation:</i> life cycle cost, machine breakdown cost, repair cost; spare parts and labour cost; impact of maintenance cost, <i>Incentive Payment:</i> objectives, financial, non-financial and semi financial incentive of maintenance staff, different types of incentive plans for maintenance staff; <i>Budget:</i> objectives and functions of budget in maintenance.	5

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understand the philosophies of maintenance of plant, machineries and equipment's.	L2
2	Plan and apply the concept of maintenance on repair and renovation of machine, plant and equipment's.	L3
3	Analyse the hazards, fault and control of failure using theories, housekeeping and safety in maintenance.	L4
4	Ability to conduct inspection and tests on machines and equipment's to assess their condition and availability.	L4
5	Estimation of reliability of part, system, machine and equipment using different theories of maintenance.	L5
6	Adapt computerized trouble shooting in maintenance.	L6

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	2	-	-	-	-	-	2	3	1
CO2	3	3	3	2	-	-	-	-	-	-	-	2	3	1
CO3	3	2	2	2	1	2	3	3	-	-	-	3	3	1
CO4	2	3	2	3	1	2	-	-	-	-	-	2	3	1
CO5	2	3	3	2	-	1	-	-	-	-	-	1	3	1
CO6	1	1	1	3	2	1	-	-	-	-	-	1	2	2

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1	A text Book of Reliability and Maintenance Engineering, Alakesh Manna, I. K. International Publishing House Pvt. Ltd, New Delhi.	2020
2	Preventive Maintenance, Terry Weriman, Reston Publishing Company.	1984
3	Principle of planned maintenance, Clifton R. H, McGraw Hill.	1983
4	Maintenance Planning and Control, Enthory Kelly, EWP, New Delhi.	1984
5	Maintenance Planning and Scheduling Handbook, 4th Edition, Richard D. Palmer, Mc Graw Hill	2019

Course Name	:	OPERATION RESEARCH AND SIMULATION TECHNIQUES
Course Code	:	MEE1041
Credits	:	4
L T P	:	3-1-0

Course Objectives: To impart the knowledge of

1. Optimization using calculus and dynamic programming.
 2. Linear programming, transportation and assignment problems.
- Evolutionary algorithms for optimization and search, Taguchi, Grey-relational analysis, Response surface methodology, Genetic algorithm-based optimization and simulations.

Total No. of Lectures – 42

Lecture wise breakup	No. of Lectures

1	INTRODUCTION AND BASIC CONCEPTS: Historical Development, Art of Modeling and simulation, Objective function, Formulation of design problems as mathematical programming problems, Classical and advanced techniques, Basics of operations research, OR models and applications.	5
2	OPTIMIZATION USING CALCULUS: Stationary points, Functions of single and two variables, Global Optimum, Convexity and concavity of functions of one and two variables, Optimization of function of one variable and multiple variables, Gradient vectors, Lagrangian function, Hessian matrix formulation, Eigen values, Kuhn-Tucker Conditions, Optimization problems.	8
3	LINEAR PROGRAMMING: Standard and Canonical form of linear programming, Assumptions in LP Models, Elementary operations, problem formulation, Graphical method, Simplex method, Big-M method, Two-phase method, Revised simplex method, Duality in LP, Dual Simplex method, Sensitivity or post optimality analysis, Other algorithms for solving LP problems, Karmarkar's projective scaling method, Use of software for solving linear optimization problems.	8
4	TRANSPORTATION AND ASSIGNMENT PROBLEMS: North west corner rule, Least cost method, Vogel's method, Stepping stone method, MODI method, <i>Assignment problem formulation:</i> Optimal solution, Hungarian algorithm, Variants of assignment problems, Travelling salesman problem.	7
5	DYNAMIC PROGRAMMING: Representation of multistage decision process, Types of multistage decision problems, Concept of sub-optimization and optimality, Recursive equations, Forward and backward recursions, Computational procedure in dynamic programming, Discrete versus continuous dynamic programming, Multiple state variables, curse of dimensionality, Problem formulation and application of dynamic programming in design of continuous beam and optimal geometric layout of a truss, water allocation as a sequential process, Capacity expansion and Reservoir operation.	7
6	ADVANCED TECHNIQUES IN OPTIMIZATION & SIMULATION: Concept and object of simulation, Multi objective optimization, Direct and indirect search methods, Taguchi, Grey-relational analysis, Response surface methodology, Genetic algorithm-based optimization, applications in engineering problems, Algorithms and software for simulations.	7

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understanding the basic concept of optimization, modelling and simulation.	L2
2	Apply scientific methods and mathematical techniques to solve various engineering problems.	L3
3	Analysis of the various optimization techniques for engineering problems.	L4
4	Recommend the various software tools for modelling and simulations of real-time industrial problems.	L5
5	Development and formulation of new models for better decision making in the organization.	L6

CO-PO & PSO course Articulation Matrix

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

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Engineering Optimization: Theory and Practice, S.S. Rao, New Age International Pvt. Ltd., New Delhi.	2019
2	Linear programming, G. Hadley, Narosa Publishing House, New Delhi.	1990
3	Operations Research: An Introduction, H.A. Taha, 5 th ed., Macmillan, New York.	1992
4	Optimization for Engineering Design Algorithms and Examples, K. Deb, Prentice-Hall of India Pvt. Ltd., New Delhi.	1993
5	Multi-criterion Analysis in Engineering and Management, K. Srinivasa Raju, D. Nagesh Kumar, PHI Learning Pvt. Ltd., New Delhi.	2010

MINOR SPECIALIZATION

Course Name	:	DESIGN OF THERMAL SYSTEMS
Course Code	:	MEM1001/MEE1024
Credits	:	4
L T P	:	3-1-0

Course Objectives:	
1	To provide the knowledge of various mathematical techniques used in design and optimization of thermal systems.
2	To model and simulate the different thermal engineering problems.
3	To give an insight of a commercial software for modelling, simulation and optimization of the thermal systems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	ENGINEERING DESIGN: Design versus Analysis, Design versus Synthesis, Selection versus Design, Design as part of Engineering Enterprises, Basic Characteristics of Thermal System, Basic Consideration in Design, Conceptual Design, Basic steps in design process, Computer Aided Design of Thermal System, Material Properties and Selection for Thermal System.	07
2	MODELING OF THERMAL SYSTEM: Introduction, Types of Models, Mathematical Modeling, Physical Modeling and Dimensional Analysis, Importance of Modeling in Design, Basic Features of Modeling, Type of Models, General procedure of mathematical modeling, physical modeling and dimensional analysis.	07
3	NUMERICAL MODELLING AND SIMULATION: Numerical Model, Solution Procedure, Numerical Model of a System, System Simulation, Methods of Numerical Simulation.	07
4	ACCEPTABLE DESIGN OF THERMAL SYSTEM: Initial Design, Design Strategies, Design of System in different application areas such as manufacturing, electronics, environment, heat transfer and fluid flow, Additional Considerations in Large Practical Systems.	07
5	PROBLEM FORMULATION FOR OPTIMIZATION: Introduction to Optimization in Design, Basic Concepts, Optimization methods, Important Considerations for Optimization of Thermal System, Different Types of Thermal System, Practical Aspects of Thermal Design.	07
6	THERMAL SYSTEM ANALYSIS AND SIMULATION USING COMMERCIAL SOFTWARE: Modelling Periodic Flow and Heat Transfer, Laminar Flow Convection, Turbulent Forced Convection, Compressible Flow in Nozzle, Modelling Cavitation, Solidification and Steady and Unsteady Flow Past a Cylinder, Flat Plate Boundary Layer.	07

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	To have knowledge of different aspects of designing of a thermal system.	L1, L3
2	To identify and examine a design problem associated to a thermal system.	L4
3	To have understand basics of modeling and their associated techniques.	L6
4	To inculcate an ability to solve engineering problems using knowledge of various disciplines.	L7
5	To inculcate an ability to identify, formulates, and solves engineering problems.	L2, L5
6	Top inculcate an ability to use the mathematical tools for optimization of engineering problems.	L3
7	To design, formulate analysis and solve engineering problems using mathematical as well as commercial software tools.	L6

8	To explain economic and exergoeconomic aspects associated with designing and optimization of thermal system.	L4
---	--	-----------

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	-	-	-	-	-	-	-	-	2	1
CO2	2	3	2	1	-	-	-	-	-	-	-	-	2	1
CO3	2	2	1	3	2	1	-	-	-	-	-	-	3	2
CO4	2	3	1	1	3	2	1	-	-	-	-	-	3	2
CO5	3	2	2	1	1	2	1	-	-	-	-	-	1	3
CO6	2	2	3	2	-	-	-	-	-	-	-	-	1	3
CO7	2	2	-	3	-	-	-	-	-	1	2	3	1	3
CO8	3	2	2	3	-	-	-	1	1	1	-	-	1	3

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Design and Optimization of Thermal System, Y Jaluria, 2 nd ed., CRC Press.	2020
2	Heat Transfer, Cengel and Boles, 2 nd ed., McGraw Hill.	2002
3	Thermal Design and Optimization, A Bejan, G Satoranis and M Moran, 2 nd ed., Wiley Inderscience.	1996
4	Computational Fluid Dynamics, Versteeg and Malalasekhera, 1 st ed., Longman Scientific & Technical.	2007

Course Name	:	THERMAL SYSTEM MODELING AND SIMULATION
Course Code	:	MEM1002/MEE1034
Credits	:	4
L T P	:	3-1/2-2/2

Course Objectives:

1	To understand the significance of modelling and simulation of different engineering problems using various techniques.
2	To understand various mathematical techniques in solution of variety of problems related to design and optimization of Thermal Systems.
3	To understand the application of software for modelling, simulation and optimization of engineering systems problems.
4	To design and analyze of industrial equipment's and hydraulic systems.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1	INTRODUCTION TO THERMAL DESIGN: Design, Mathematical Modelling and Numerical Simulation of Thermal Systems, Approach to Robust Design, Numerical Methods for thermal and energy systems, Closed form solutions of heat transfer problems, Finite Difference and Finite Volume Formulations, TDMA Method	07
2	DESIGN AND ANALYSIS OF THERMAL EQUIPMENT: Design Strategies, Design of Heat Exchanger, Refrigeration System, Solar Thermal System, Heat Pump, Cooling of Electronic Components, Energy Storage System and Design Consideration for Engineering Material Selection.	07
3	DESIGN AND ANALYSIS OF HYDRAULIC SYSTEM: Introduction to Hydraulic Systems, Constituents of Hydraulic System, Directional Control Valve,	07

	Pressure Control Valve and Flow Control Valve, Hydraulic Circuit Design and Analysis.	
4	OPTIMIZATION: Basic Concepts, Objective Function, Methods, Optimization of Mechanical System and case studies, Practical Aspects in Optimal Design, Constrained and Unconstrained Problems: Langrage Multiplier, Geometric & Dynamic Programming based optimization.	07
5	THERMAL SYSTEM SIMULATION: Simulation of Periodic Heat Transfer, Laminar and Turbulent Convection, Compressible Flow in Nozzle, Cavitation and Solidification, Flow Past a Cylinder, Flat Plate Boundary Layer.	07
6	ECONOMIC AND EXERGO-ECONOMIC ANALYSIS: Estimation of Total Capital Investment, Principal of Economic Evaluation, Calculation of Revenue Requirements, Levelized Cost Rates, Cost Rate of Exergy Destruction, Exergy Destruction, Percentage Relative Cost Difference, Total Operating Cost Rate and Exergo-economic Factor.	07

Experiments:	No. of Turns
Thermal system modelling and simulation experiments on Heat Exchanger, refrigeration system, hydraulic system, solar energy, energy storage etc. will be performed using ANSYS Fluent /CFX, COMSOL etc.	07

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	Knowledge Level (Blooms Level)
1	To have knowledge of different aspects of designing of a thermal system.	L1, L3
2	To identify and examine a design problem associated to a thermal system.	L4
3	To integrate thermal component models and simulate a thermal system.	L6
4	To design, formulate analysis and solve engineering problems using knowledge of various disciplines.	L7
5	To inculcate an ability to identify, formulates, and solves engineering problems using mathematical techniques.	L2, L5
6	To perform technoeconomic analysis of thermal system using commercial software techniques.	L3
7	To communicate thermal system designs both orally and in writing.	L6
8	To understand some of the ethical and societal issues associated with design and optimization of thermal system.	L4

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	-	-	-	-	-	-	-	-	2	1
CO2	2	3	2	1	-	-	-	-	-	-	-	-	2	1
CO3	2	2	1	3	2	1	-	-	-	-	-	-	3	2
CO4	2	3	1	1	3	2	1	-	-	-	-	-	3	2
CO5	3	2	2	1	1	2	1	-	-	-	-	-	1	3
CO6	2	2	3	2	-	-	-	-	-	-	-	-	1	3
CO7	2	2	-	3	-	-	-	-	-	1	2	3	1	3
CO8	3	2	2	3	-	-	-	1	1	1	-	-	1	3

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Design and Optimization of Thermal System with MATLAB Applications, Y Jaluria, 3 rd ed., CRC Press.	2020
2	Heat Transfer, Cengel and Boles, 2 nd ed., McGraw Hill.	2002
3	Thermal Design and Optimization, A Bejan, G. Satsoranis and M Moran, 2 nd ed., Wiley Inder science.	1996
4	Computational Fluid Dynamics, Versteeg and Malalasekhera, 1 st ed., Longman Scientific & Technical.	2007

Course Name	:	COMPUTATIONAL FLUID DYNAMICS
Course Code	:	MEE1003/MEM1014
Credits	:	4
L T P	:	3-0-2

Course Objectives:	
1	To understand mathematical characteristics of partial differential equations.
2	To understand basic properties of computational methods.
3	To learn computational solution techniques for time integration of ordinary and partial differential equations.
4	To learn to solve computationally the Euler and Navier-Stokes equations
5	To acquire basic programming and graphic skills to conduct the flow field calculations and data analysis.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
1.	INTRODUCTION: CFD and its Applications, Numerical vs Analytical vs Experimental approach, Modeling Vs Experimentation, Fundamental principles of conservation, Reynolds transport theorem, Principles of mass, momentum and energy conservation, General scalar transport equation.	4
2.	PARTIAL DIFFERENTIAL EQUATIONS AND PHYSICAL BEHAVIOUR: Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Applications of elliptic, parabolic and hyperbolic partial differential equations	2
3	ORDINARY DIFFERENTIAL EQUATIONS: Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations.	3
4	FUNDAMENTALS OF DISCRETIZATION: Pre-processing, Solution, Post-processing, Finite difference method (FDM), Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportive Ness, Finite volume method (FVM), Illustrative examples:1-D steady state heat conduction without and with constant source term. 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. The basic structure of a CFD code: Pre-processor, Solver and Post-processor, User-defined-subroutines, Solution to some basic problems in heat transfer and fluid flow.	6
5	FINITE VOLUME METHOD: Concepts and Illustrations through 1-D Steady	14

	State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion-based problem, Composite material with position dependent thermal conductivity, Source term linearization, Implementation of boundary conditions. FVM for 2-D unsteady state diffusion problems. <i>Finite volume discretization of convection-diffusion problem</i> : Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme. Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm.	
6	DISCRETIZATION OF TIME DEPENDENT DIFFUSION TYPE PROBLEMS: Consequences of time-discretization in finite discretization, Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): Forward time central space (FTCS) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): Central time central space (CTCS) scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Stability analysis of 2 nd order hyperbolic equations: CTCS scheme.	7
7	LINEAR ALGEBRAIC EQUATIONS: Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: L-U decomposition technique, Tridiagonal matrix algorithm (TDMA): Thomas algorithm, Illustrative examples, <i>Iteration methods</i> : Jacobi's method and Gauss Siedel method, Illustrative examples of Jacobi's method and Gauss-Siedel method, ADI (Alternating direction implicit) method.	6

List of Experiments		No. of Turns
1	Ansys Simulation of lid driven cavity.	2
2	Ansys Simulation of heat transfer and fluid flow through pipe.	2
3	Ansys Simulation of flow past regular and irregular bodies.	2
4	Ansys Simulation of Conduction, Convection and Radiation	2
5	Ansys Simulation of flow through porous media.	3
6	Ansys Simulation of Phase Change Materials	3

Sr. No.	Course outcomes: By the end of this course, the student will be able to:	KnowledgeLevel (Blooms Level)
1	Understand the use and stepwise procedure to completely solve a fluid flow and heat transfer problem using computational methods.	L1, L2
2	Develop basic governing equations for fluid flow and heat transfer by examining the physical boundary conditions.	L3
3	Construct and analyze the consistency, stability and convergence of various discretization schemes of finite difference-based equations according to the nature (i.e. elliptic, parabolic and hyperbolic) of the flow problem.	L4, L6
4	Predict and implement various implicit and explicit CFD schemes to solve steady and unsteady 1/2/3-dimensional fluid and heat transfer problems.	L3, L5
5	Analyze and evaluate various finite volume based CFD schemes to solve fluid and heat transfer problems.	L3, L5
6	Practice CFD software to simulate practical fluid flow and heat transfer problems	L3

CO-PO & PSO course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	-	-	-	-	1	3	2
CO2	2	3	3	2	1	-	-	-	-	-	-	1	2	3
CO3	2	2	3	2	1	-	-	-	-	-	-	1	2	3
CO4	2	2	3	3	2	-	-	-	-	-	-	1	2	2
CO5	2	2	3	3	2	-	-	-	-	-	-	1	2	2
CO6	2	2	2	2	3	-	-	-	-	3	-	2	2	3

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Numerical Heat Transfer and Fluid Flow, S. V. Patankar, McGraw-Hill.	2018
2	Computational Fluid Dynamics, T. J. Chung, Cambridge University Press.	2010
3	An Introduction to Computational Fluid Dynamics, H. K. Versteeg & W. Malalasekera, 2 nd ed. Longman Scientific & Technical	2007
4	Computational Methods for Fluid Dynamics, J. H. Ferziger and M. Peric, 3 rd ed. Springer	2002
5	Computational Fluid Mechanics and Heat Transfer, John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, 3 rd ed., Taylor & Francis	2016
6	Computational Fluid Dynamics, John D. Anderson Jr, McGraw Hill Book Company	2017
7	Computational Fluid Dynamics: Principles and Applications, J. Blazek, 3 rd ed. Elsevier.	2015