CURRICULUM & SYLLABI

for

B. Tech Programme

in

Mechanical Engineering

(2024 Onwards)

DEPARTMENT OF MECHANICAL ENGINEERING

National Institute of Technology Manipur

Langol, Imphal- 795004

India

DEPARTMENT OF MECHANICAL ENGINEERING
राष्ट्रीय प्रौद्योगिकी संस्थान मणिपुर
NATIONAL INSTITUTE OF TECHNOLOGY, MANIPUR
Langol, Imphal-795004. Email:- hodmechanical@nitmanipur.ac.in
An Autonomous Institute under Ministry of Education, Govt. of India.

Vision of the Institute

Towards a knowledge hub of excellence in education, research, Innovation, and entrepreneurship, nurturing skilled professionals committed to sustainable ecosystems.

Mission of the Institute

- To impart quality education in engineering technology and allied fields to produce competent and ethical professionals.
- To foster a culture of research and innovation that addresses emerging challenges and contributes to technological growth.
- To promote entrepreneurship and leadership skills for developing sustainable solutions, socio-economic growth and global wellbeing.

Vision of the Department

To emerge as a centre of excellence in Mechanical Engineering education, research, and innovation, and entrepreneurship, fostering skilled professionals who drive sustainable technological solutions for societal and industrial advancement.

Mission of the Department

- To deliver high-quality education in Mechanical Engineering, equipping students with technical expertise, ethical values, and problem-solving skills.
- To foster a research-driven culture that encourages innovation in mechanical systems, interdisciplinary collaboration, and sustainable engineering solutions.
- To produce globally competent professionals, entrepreneurs, leaders who are committed to advancing eco-friendly solutions for industrial and societal progress.

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Program: Bachelor of Technology in Mechanical Engineering

PEO No.	Program Educational Objectives (PEOs) Statements
PEO1	To produce graduates with strong technical competencies in mechanical engineering, enabling them to analyze, design, and implement solutions for real-world engineering challenges.
PEO2	To cultivate research aptitude and innovation in graduates, empowering them to develop sustainable and cutting-edge technologies in mechanical engineering.
PEO3	To nurture entrepreneurial and leadership skills in graduates, preparing them to drive socio-economic development through sustainable engineering practices.

Program Articulation Matrix

Mission Statement / PEO	PEO1	PEO2	PEO3
To deliver high-quality education in Mechanical Engineering, equipping students with technical expertise, ethical values, and problem-solving skills	3	2	2
To foster a research-driven culture that encourages innovation in mechanical systems, interdisciplinary collaboration, and sustainable engineering solutions	2	3	2
To produce globally competent professionals, entrepreneurs, leaders who are committed to advancing eco-friendly solutions for industrial and societal progress	3	2	3

1 – Low 2 – Medium 3 – High

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Program Outcomes (POs)

PO1:	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and mechanical engineering to the solution of complex engineering problems.
PO2:	**Problem Analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated con
PO3:	**Design/Development of Solutions:** Design solutions for complex mechanical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4:	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5:	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.
PO6:	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7:	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8:	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9:	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10:	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11:	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12:	**Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1:	Graduates will demonstrate proficiency in applying mechanical engineering principles/concepts to solve real-world problems using sustainable approaches
PSO2:	Graduates will exhibit the ability to engage in research, innovation, and entrepreneurship in fluid-thermal, manufacturing, and design areas in alignment with technological advancements and environmental responsibility

Curriculum of Bachelor of Technology

Sl No.	Course components	No of course	Credits
1	Basic Science Courses (BSC)	6	20
2	Engineering Science Courses (ESC)	7	26
3	Departmental Core Courses (DCC)	20	77
4	Departmental Elective Courses (DEC)	4	12
5	Open Elective Courses (OEC)	2	6
6	Skill Enhancement Courses (SEC)	2	6
7	Ability Enhancement Mandatory Course (AEMC)	5	14+8*
8	Value Addition Courses (VAC)	3	0
	Total	**49**	**161+8***

PROGRAMME STRUCTURE:

Semester-I

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	CH 1101	Engineering Chemistry	BSC-1	3	0	2	4
2	ME 1101	Engineering Mechanics	ESC-1	3	1	0	4
3	MA 1101	Engineering Mathematics-I	BSC-2	3	0	0	3
4	PH 1101	Engineering Physics	BSC-3	3	0	2	4
5	HS 1101	Professional Communication Skills	SEC-1	3	0	0	3
6	ME 1149	Engineering Drawing	ESC-2	0	1	4	3
7	IC 1191	Induction Programme	VAC-1				0
8	IC 1192	Extra Academic Activity-I	VAC-2				0
	Total			**16**	**3**	**4**	**21**

Semester-II

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	CS 1201	Introduction to Computing	ESC-3	3	0	4	5
2	EE 1201	Basic Electrical Engineering	ESC-4	3	0	2	4
3	MA 1201	Engineering Mathematics-II	BSC-4	3	0	0	3
4	EC 1201	Basic Electronic Circuits	ESC-5	3	0	2	4
5	CE 1201	Environmental Sustainability	ESC-6	3	0	0	3
6	ME 1249	Engineering Workshop	ESC-7	0	1	4	3
7	IC 1291	Extra Academic Activity-II	VAC-3				0
			Total	**16**	**0**	**12**	**22**

Semester-III

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	MA 2301	Engineering Mathematics-III	BSC-5	3	0	0	3
2	ME 2301	Materials Engineering	DCC-1	3	0	0	3
3	ME 2302	Engineering Thermodynamics	DCC-2	3	0	0	3
4	ME 2303	Mechanics of Deformable Bodies	DCC-3	3	1	2	5
5	ME 2304	Fluid Mechanics	DCC-4	3	1	2	5
6	ME 2305	Machine Drawing	DCC-5	1	2	0	3
			Total	**16**	**4**	**4**	**22**

Semester-IV

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	MA 2402	Numerical Methods	BSC-6	3	0	0	3
2	ME 2401	Applied Thermodynamics	DCC-6	3	0	2	4
3	ME 2402	Manufacturing Technology I	DCC-7	3	0	2	4
4	ME 2403	Fluid Machinery	DCC-8	3	0	2	4
5	ME 2404	Kinematics of Machinery	DCC-9	3	0	0	3
6	ME 2405	Mechanical Measurements	DCC-10	3	0	2	4
7	*ME 2439	Minor Project	AEMC-1	0	0	16	8
			Total	**18**	**0**	**8+16***	**22+8***

*NOTE: Minor Project (ME 2439) is to be opted by the students who want to leave the program after Semester- IV with UG Diploma in Mechanical Engineering**.**

Semester-V

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	ME 3501	Heat and Mass Transfer	DCC-11	3	1	2	5
2	ME 3502	Manufacturing Technology II	DCC-12	3	0	2	4
3	ME 3503	Dynamics of Machinery	DCC-13	3	0	2	4
4	ME 3504	Mechanical Vibrations	DCC-14	3	1	0	4
5	ME 35XX	Department Elective I	DEC-1	3	0	0	3
			Total	**15**	**2**	**6**	**20**

Semester-VI

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	HS 3601	Managerial Economics and Financial Accounting	SEC-2	3	0	0	3
2	ME 3601	Design of Machine Elements	DCC-15	3	0	0	3
3	ME 3602	Mechatronics and Robotics	DCC-16	3	1	2	5
4	ME 3603	Automobile Engineering	DCC-17	3	0	2	4
5	ME 3604	Refrigeration and Air Conditioning	DCC-18	3	0	0	3
6	ME 36XX	Departmental Elective II	DEC-2	3	0	0	3
			Total	**18**	**1**	**4**	**21**

Semester-VII

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	ME 4701	Industrial Engineering and Management	DCC-19	3	0	0	3
2	ME 4702	CAD/CAM	DCC-20	3	0	2	4
3	ME 47XX	Departmental Elective III	DEC-3	3	0	0	3
4	ME 47XX	Open Elective I	OEC-1	3	0	0	3
5	ME 4738	Summer Internship/Industrial Training/Research Work**	AEMC-2	0	0	6	3
6	ME 4739	Project Work-I	AEMC-3	0	0	8	4
			Total	**12**	**0**	**16**	**20**

** Students will undertake this course after completing Semester VI, during the summer vacation. Moreover, the evaluation will commence at the beginning of Semester VII. Also, as per the approval of 37th Senate, a provision has been made to offer 1 credit-based courses based on Industry, Entrepreneurship, Design thinking, Health and wellness, Yoga, etc., as separate basket and offer at any time from eminent external experts, and total number of such 1-credit courses is equivalent to Summer Internship/Industrial training/Research work and it is to be monitored by the Humanities and Social Sciences Department.

Semester-VIII

Sl. No.	Course Code	Course Name	Category	L	T	P	Credits
1	ME 48XX	Departmental Elective-IV	DEC-4	3	0	0	3
2	ME 48XX	Open Elective-II	OEC-2	3	0	0	3
3	ME 4835	Seminar	AEMC-4	0	0	2	1
4	ME 4839	Project Work-II	AEMC-5	0	0	12	6
			Total	**6**	**0**	**14**	**13**
******For those students carrying out project work in Industries/Organizations***							
1	ME 4840	Industrial Project		0	0	8	4
2	ME 4841	Project Seminar		0	0	10	5
3	ME 4842	Comprehensive Viva		0	0	8	4
			Total	**0**	**0**	**26**	**13**

List of Basic Science Courses

Sl. No.	Course Code	Course Name	L	T	P	Credits
1	CH 1101	Engineering Chemistry	3	0	2	4
2	MA 1101	Engineering Mathematics-I	3	0	0	3
3	PH 1101	Engineering Physics	3	0	2	4
4	MA 1201	Engineering Mathematics-II	3	0	0	3
5	MA 2301	Engineering Mathematics-III	3	0	0	3
6	MA 2402	Numerical Methods	3	0	0	3
		Total				**20**

List of Engineering Science Courses

Sl. No.	Course Code	Course Name	L	T	P	Credits
1	ME 1101	Engineering Mechanics	3	1	0	4
2	ME 1149	Engineering Drawing	1	2	0	3
3	CS 1201	Introduction to Computing	3	0	4	5
4	EE 1201	Basic Electrical Engineering	3	0	2	4
5	EC 1201	Basic Electronic Circuits	3	0	2	4
6	CE 1201	Environmental Sustainability	3	0	0	3
7	ME 1249	Engineering Workshop	1	0	4	3
		Total				**26**

List of Skill Enhancement Courses

Sl. No.	Course Code	Course Name	L	T	P	Credits
1	HS 1101	Communication Skills	3	0	0	3
2	HS 3601	Managerial Economics and Financial Accounting	3	0	0	3
		Total				**6**

List of Ability Enhancement Mandatory Courses

Sl. No.	Course Code	Course Name	L	T	P	Credits
1	ME 2439	Minor Project*	0	0	16	8
2	ME 4738	Summer Internship/Industrial Training/Research Work**	0	0	6	3
3	ME 4739	Project Work-I	0	0	8	4
4	ME 4835	Seminar	0	0	2	1
5	ME 4839	Project Work-II	0	0	12	6
		Total				**14+8***

* For UG Diploma in Mechanical Engineering.

List of Value Addition Courses

Sl. No.	Course Code	Course Name	L	T	P	Credits
1	IC 1191	Induction Programme				0
2	IC 1192	Extra Academic Activity-I				0
3	IC 1291	Extra Academic Activity-II				0
		Total				**0**

List of Departmental Core Courses

Sl. No.	Course Code	Course Name	L	T	P	Credits
1	ME 2301	Materials Engineering	3	0	0	3
2	ME 2302	Engineering Thermodynamics	3	0	0	3
3	ME 2303	Mechanics of Deformable Bodies	3	1	2	5
4	ME 2304	Fluid Mechanics	3	1	2	5
5	ME 2305	Machine Drawing	1	2	0	3
6	ME 2401	Applied Thermodynamics	3	0	2	4
7	ME 2402	Manufacturing Technology I	3	0	2	4
8	ME 2403	Fluid Machinery	3	0	2	4
9	ME 2404	Kinematics of Machinery	3	0	0	3
10	ME 2405	Mechanical Measurements	3	0	2	4
11	ME 3501	Heat and Mass Transfer	3	1	2	5
12	ME 3502	Manufacturing Technology II	3	0	2	4
13	ME 3503	Dynamics of Machinery	3	0	2	4
14	ME 3504	Mechanical Vibrations	3	1	0	4
15	ME 3601	Design of Machine Elements	3	0	0	3
16	ME 3602	Mechatronics and Robotics	3	1	2	5
17	ME 3603	Automobile Engineering	3	0	2	4
18	ME 3604	Refrigeration and Air Conditioning	3	0	0	3
19	ME 4701	Industrial Engineering and Management	3	0	0	3
20	ME 4702	CAD/CAM	3	0	2	4
		Total				**77**

List of Departmental Electives

Sl. No.	Course Code	Course Name	L	T	P	Credits	Category
1	ME 3571	AI and ML in Mechanical Engineering	3	0	0	3	**Dept. Elective I**
2	ME 3572	Introduction to Two Phase Flow	3	0	0	3	
3	ME 3573	Introduction to Turbulent Flow	3	0	0	3	
4	ME 3574	Advanced Solid Mechanics	3	0	0	3	
5	ME 3575	Non-Destructive Testing	3	0	0	3	
6	ME 3576	Elements of Plastic Technology	3	0	0	3	
7	ME 3577	Acoustics	3	0	0	3	
8	ME 3578	Tribology	3	0	0	3	
9	ME 3579	NPTEL/SWAYAM/MOOCS	3	0	0	3	
10	ME 3671	Theory of Microfluidics	3	0	0	3	**Dept. Elective II**
11	ME 3672	Material Handling	3	0	0	3	
12	ME 3673	Introduction to Combustion Engineering	3	0	0	3	
13	ME 3674	Energy Conservation and Waste Heat Recovery	3	0	0	3	
14	ME 3675	Composite Materials	3	0	0	3	
15	ME 3676	Introduction to FEM	3	0	0	3	
16	ME 3677	Multi-body Dynamics	3	0	0	3	
17	ME 3678	Introduction to Power Plant Engineering	3	0	0	3	
18	ME 3679	Advanced Manufacturing	3	0	0	3	
19	ME 3680	NPTEL/SWAYAM/MOOCS	3	0	0	3	
20	ME 4771	Solar Energy Conversion Technology	3	0	0	3	**Dept. Elective III**
21	ME 4772	Cryogenics Engineering	3	0	0	3	
22	ME 4773	Experimental Methods in Mechanical Engineering	3	0	0	3	
23	ME 4774	Design of Transmission Elements	3	0	0	3	
24	ME 4775	Advanced Finite Element Methods	3	0	0	3	
25	ME 4776	Introduction to Mechanical Micro-Machining	3	0	0	3	
26	ME 4777	Introduction to Computational Fluid Dynamics	3	0	0	3	
27	ME 4778	Additive Manufacturing	3	0	0	3	
28	ME 4779	NPTEL/SWAYAM/MOOCS	3	0	0	3	
29	ME 4871	Failure Analysis and Design	3	0	0	3	**Dept. Elective IV**
30	ME 4872	Convective Heat Transfer	3	0	0	3	
31	ME 4873	Introduction to Solidification Processing	3	0	0	3	
32	ME 4874	Renewable Energy Engineering	3	0	0	3	
33	ME 4875	Non-Traditional Machining	3	0	0	3	
34	ME 4876	Green Manufacturing	3	0	0	3	
35	ME 4877	Reliability analysis and Materials Management	3	0	0	3	
36	ME 4878	Product innovation and Start-up Strategies	3	0	0	3	
37	ME 4879	Project Management	3	0	0	3	
38	ME 4880	NPTEL/SWAYAM/MOOCS	3	0	0	3	

List of Open Electives

Sl. No.	Course Code	Course Name	L	T	P	Credits	Category
1	ME 4750	Sustainable Engineering	3	0	0	3	**Open Elective I**
2	ME 4751	Optimization in Engineering	3	0	0	3	
3	ME 4752	Elements of Product Design	3	0	0	3	
4	ME 4753	Introduction to Medical Devices and its Design	3	0	0	3	
5	ME 4754	Automation and Control	3	0	0	3	
6	ME 4755	Intellectual Property Rights (IPR)	3	0	0	3	
7	ME 4756	Operations Research	3	0	0	3	
8	ME 4757	Smart Materials	3	0	0	3	
9	ME 4758	Electric Vehicle Control Systems	3	0	0	3	
10	ME 4759	NPTEL/SWAYAM/MOOCS	3	0	0	3	
11	ME 4850	Energy Storage Technologies	3	0	0	3	**Open Elective II**
12	ME 4851	Total Quality Management	3	0	0	3	
13	ME 4852	Computer Aided Geometric Design	3	0	0	3	
14	ME 4853	Introduction to Micro Electro Mechanical Systems	3	0	0	3	
15	ME 4854	Supply Chain Management	3	0	0	3	
16	ME 4855	Introduction to Design Thinking	3	0	0	3	
17	ME 4856	Industry 4.0	3	0	0	3	
18	ME 4857	Energy Audit and Energy Management	3	0	0	3	
19	ME 4858	NPTEL/SWAYAM/MOOCS	3	0	0	3	

Syllabus of Departmental Courses for First Year Students

ME 1149 **0-1-4-3**

Engineering Drawing

Prerequisite: NA

Course Outcomes:

CO1	Apply engineering drawing standards and conventions (ISO) to technical drawings for accurate and professional communication of design information.
CO2	Construct scales, loci of points, and engineering curves to represent geometrical entities and design requirements effectively.
CO3	Generate orthographic projections of points, lines, planes, and solids, including sectional views, intersection and developments of surface, for visualization and design representation.
CO4	Prepare isometric projections and multi-view drawings to communicate three-dimensional objects in two-dimensional space.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Basics: Introduction to drawing instruments, sheet layout, and BIS (Bureau of Indian Standards) conventions; Lettering & Dimensioning: Standard techniques for text and providing measurements; Scales: Construction of Plain, Diagonal, and Vernier scales;

Engineering Curves: Conic sections (Ellipse, Parabola, Hyperbola), Cycloids, and Involutes; Orthographic Projections: Understanding First-angle and Third-angle projections; Projection of Points, Lines & Planes; Projection of Solids & Section of Solids: Projections of Prisms, Pyramids,

Cylinders, and Cones; Sectioning by "cutting" the solid with a section plane; Development of Surfaces: Methods to "unfold" the surface of 3D objects; Isometric Projections: Transforming 2D orthographic views back into a 3D pictorial representation;

Computer-Aided Design (CAD): Introduction to software interfaces; Creating 2D sketches and basic 3D modeling using commands like extrude, revolve, and sweep.

Text Books:

1. Engineering Drawing, *N.D. Bhatt*, 54th Edition, Charotar Publication, 2024.

Reference Books:

1. Technical Drawing with Engineering Graphics, *Frederick E. Giesecke, Shawna Lockhart, Marla Goodman, and Cindy Johnson,* 16th Edition, Peachpit Press, 2023.
2. Engineering Drawing + Auto CAD, *K, Venugopal and V, P, Raja,* 6th Edition, New Age International Publishers, 2022.

Online Resource:

1. https://nptel.ac.in/courses/112103019

ME 1101 **3-1-0-4**

Engineering Mechanics

Prerequisite: NA

Course Outcomes:

CO1	To understand and apply fundamental principles of statics**,** including equivalent force systems, equations of equilibrium, and free body diagrams, to analyse the stability and support reactions in structures.
CO2	To analyse various structural systems such as trusses, beams, and frames using appropriate methods (e.g., method of joints, method of sections) and construct shear force and bending moment diagrams for different loading conditions.
CO3	To explain and apply the principles of dry friction in mechanical systems.
CO4	To understand the various geometric and inertial properties of the rigid bodies.
CO5	To understand the principle of virtual work as well as to analyse the kinematics and kinetics behaviour of rigid bodies in motion.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Basic principles: Equivalent force system; Equations of equilibrium; Free body diagram; Reaction; Static indeterminacy.

Structures: Difference between trusses, frames and beams, Assumptions followed in the analysis of structures; 2D truss; Method of joints; Method of section; Frame; Simple beam; types of loading and supports; Shear Force and bending Moment diagram in beams; Relation among load, shear force and bending moment.

Friction: Dry friction; Description and applications of friction in wedges, thrust bearing (disk friction), belt, screw, journal bearing (Axle friction); Rolling resistance.

Center of Gravity and Moment of Inertia: First and second moment of area; Radius of gyration; Parallel axis theorem; Product of inertia, Rotation of axes and principal moment of inertia; Moment of inertia of simple and composite bodies. Mass moment of inertia.

Virtual work and Energy method: Virtual Displacement; Principle of virtual work; Applications of virtual work principle to machines; Mechanical efficiency; **Kinematics of Particles:** Rectilinear motion; Curvilinear motion. Kinetics of Particles: Force, mass and acceleration; Work and energy; Impulse and momentum; Impact problems**. Kinematics and Kinetics of Rigid Bodies:** Translation; Impulse-momentum and associated conservation principles.

Text Books:

1. R. C. Hibbler, Engineering Mechanics, Vols. I and II, Pearson Press, 2002.
2. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol. I – Statics, Vol. II – Dynamics, 5th Ed., John Wiley, 2002.

Reference Books:

1. H. Shames, Engineering Mechanics: Statics and Dynamics, 4th Ed., PHI, 2002.
2. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol. I -Statics, Vol. II – Dynamics, 3rd Ed., Tata McGraw Hill, 2000.
3. Timoshenko and Young, Engineering Mechanics, 3rd Ed., McGraw Hill Publishers, 2006

ME 1249 **0-1-4-3**

Engineering Workshop

Prerequisite:

Course Outcomes:

CO1	Wood working: To design and create wooden projects, use hand tools and machines safely and effectively.
CO2	Fitting shop: To assemble and fit parts, use precision measurement tools, and apply safety procedures.
CO3	Sheet metal work: To fabricate and assemble sheet metal projects, use hand tools and machines safely and effectively.
CO4	Welding shop: To Apply Arc welding techniques, use safety equipment and procedures.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to wood working, hand tools and machines.

Introduction to fitting shop tools, equipment and operations.

Introduction to sheet metal work tools, equipment and operations.

Introduction to welding shop tools, equipment and operations. Simple exercises in wood working, pattern making, fitting, sheet metal work and welding, machining.

Text Books:

1. H. Choudhury, *Elements of Workshop Technology,* Asia Publishing House, 1st Edition.
2. W A J Chapman, *Workshop Technology,* Oxford IBH, 1st Edition.

Reference Books:

1. H Gerling, *All about Machine Tools*, New Age International, 2nd Edition.

Syllabus of Departmental Core Courses

ME 2301 **3-0-0-3**

Materials Engineering

Prerequisite: NA

Course Outcomes:

CO1	To acquire sound knowledge on phase diagram and heat treatment of materials.
CO2	To understand the influence of material processing on the material properties..
CO3	To deepen the knowledge about stress-strain curves and metal plasticity.
CO4	To understand the various material testing methods.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Atomic Arrangement and Phase Diagrams - Structure of metals and alloys: Phase diagram: phase rules. Phase Diagrams and Ferrous Alloys Fe- FeC diagram.

Critical temperature - Plain carbon steel and other steels. Heat Treatment of steel, CCT diagrams, austempering, martempering, ausforming. Surface hardening process - non - ferrous alloys.

Testing of Materials I - Properties evaluated by tensile testing procedure, Engineering stress strain curve vs. true stress-strain curve, stress strain curve for typical materials. Hardness testing.

Testing of Materials II - Impact testing, Fracture toughness. Fatigue testing: Creep testing. General classifications, properties and applications of alloy steels, tool steels, stainless steels, cast irons, copper base alloys, Aluminum base alloys, Nickel base alloys, composites, ceramics and polymers.

Text Books:

1. Avner, S.H, *Introduction to Physical Metallurgy*, McGraw Hill Education, 2nd Edition
2. Dieter, G.E, *Mechanical Metallurgy*, McGraw Hill Education, 2nd Edition

Reference Books:

1. V.Singh, Physical Metallurgy, Standard Publishers, 2nd Edition

ME 2302 **3-0-0-3**

Engineering Thermodynamics

Prerequisite: NA

Course Outcomes:

CO1	Explain fundamental thermodynamic concepts, including systems, equilibrium, properties, processes, the Zeroth Law and the First Law.
CO2	Use thermodynamic tables, diagrams, and equations of state to determine properties of pure substances.
CO3	Apply the First Law of Thermodynamics to analyze energy conservation in closed and open systems.
CO4	Analyze the Second Law of Thermodynamics to evaluate process reversibility, entropy generation, and cycle efficiency.
CO5	Explain fundamental of various thermodynamic cycles.

1 – Low 2 – Medium 3 – High

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction and Basic Concepts

Thermodynamics definitions, systems, properties, state, equilibrium, Zeroth law, forms of energy, heat and work, First law and energy balance.

Properties of Pure Substances

Pure substances, phase changes, property diagrams, thermodynamic tables, ideal gas equation,

compressibility factor.

Energy Analysis of Closed and Open Systems

Moving boundary work, steady and unsteady flow processes, nozzles, turbines, compressors, throttling devices and mixing chambers.

Second Law of Thermodynamics and Entropy

Heat engines, refrigerators, Carnot cycle, entropy, isentropic processes, entropy balance. Thermodynamic Cycles, Carnot, Rankine, Otto, Diesel, Brayton, refrigeration and heat pump cycles.

Text Books:

1. Cengel, Y.A., Boles, M.A., *Thermodynamics: An Engineering Approach*, McGraw Hill, 9th Edition
2. Borgnakke, C., Sonntag, R.E., *Fundamentals of Thermodynamics*, John Wiley & Sons, 10th Edition

Reference Books:

1. P.K. Nag, *Engineering Thermodynamics*, McGraw Hill, 6th Edition

ME 2303 **3-1-2-5**

Mechanics of Deformable Bodies

Prerequisite: Engineering Mechanics (ME 1101)

Course Outcomes:

CO1	Evaluate the strength of various structural elements based on internal forces such as compression, tension, shear, bending, and torsion.
CO2	Evaluate the behaviour and strength of structural elements under the action of compound stresses and thus understand failure concepts.
CO3	Analyse the basic concept and design of structural members subjected to bending moment and torsion.
CO4	Understand the basic concept of strain energy stored in material under gradual load, impact load and suddenly applied load.
CO5	Analysis and design of structural elements such as columns and struts.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Stress, strain, strain energy, and compound stresses- Axial and shear stresses and strains, elasticity, Hook's law, lateral strain, Poisson's ratio, volumetric strain, elastic constants, and stress in composite bars. Saint Venant's principle. Temperature stresses, Compound section subjected to temperature stresses. Strain energy, impact and suddenly applied loads. Principal stresses and their planes. Plane of maximum shear, Mohr's circle of stresses**.**

Thin and Thick Cylinders- Thin cylinders subjected to internal pressure; Hoop stresses, Longitudinal stress, and volume change. Thick cylinders subjected to both internal and external pressure; Lame's equation, radial and hoop stress distribution. Compound cylinders.

Shear Force and Bending Moment in Beams- Introduction to types of beams, supports, and loadings. Definition of bending moment and shear force. Shear force and bending moment diagrams for statically determinate beams subjected to various types of loads.

Bending, Deflection and Torsion in Shaft- Shear force and bending moment diagrams for beams subjected to different types of loads, Theory of simple bending and assumptions. Slope and deflection – Castigliano's theorem, moment area method, Macaulay's method, superposition (statically determinate beams only). Torsion of solid and hollow circular shafts – Power transmission, strength and stiffness of shafts.

Introduction to buckling of columns- Basic concepts of buckling, short and long columns, struts, Euler's theory of buckling for ideal columns and their assumptions, Critical load and slenderness ratio, and types of end conditions- columns with pinned, fixed, free, or mixed end conditions.

Text Books:

1. Timoshenko, S.P., Gere, *M.J., Mechanics of Materials*, CBS Publishers, 2nd Edition,

2011.
2. Popov, E.P., *Engineering Mechanics of Solids*, Pearson Education, 2nd Edition, 2015.

Reference Books:

1. Timoshenko, S., *Strength of Materials, Part I*, CBS Publishers, 3rd Edition, 2021.
2. Srinath, L.S., *Advanced Mechanics of Solids*, McGraw Hill Education, 3rd Edition, 2017.
3. Junarkar, S.B., *Mechanics of Structures*, Charotar Publishers, 1st Edition, 2012.

ME 2304 **3-1-2-5**

Fluid Mechanics

Prerequisite: Engineering Mathematics-III (MA 2301)
Course Outcomes:

CO1	Comprehend fundamental fluid properties and hydrostatic principles, and analyze forces on submerged and floating bodies
CO2	Apply the concepts of fluid kinematics and dynamics using continuity, Euler, and Navier–Stokes equations for different flow situations
CO3	Evaluate flow characteristics in laminar, turbulent, and boundary layer flows, including drag and flow separation
CO4	Utilize dimensional analysis and similarity principles (Buckingham π-theorem, Reynolds number, etc.) to model and predict real fluid flow behavior

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Properties of fluid, pressure and it's measurement: Mass and weight density, specific gravity, specific volume, viscosity and Newton's law of viscosity, Compressibility, Types of

fluid, surface tension and capillarity. Fluid pressure at a point and Pascal's law, absolute, gauge and vacuum pressures, pressure variation in a fluid at rest, pressure measurement-Manometers and Mechanical Gauges.

Hydrostatics, buoyancy and flotation: Total pressure and centre of pressure for horizontal, vertical, inclined plane surfaces and curved surfaces submerged in liquid. Total pressure and center of pressure on lock gates. Buoyancy, center of buoyancy, Metacentre and metacentric height and equilibrium of floating bodies, period of oscillation.

Kinematics of flow: Kinematics of flow. Types of fluid flow, continuity equation in three dimensions, velocity potential function and stream function, forced and free vortex flow. Dynamics of flow: Euler's equation and Bernoulli's equation, application of Bernoulli's equation Venturimeter, orifice-meter and Pitot tube.

Orifice and notches: Flow through orifices, hydraulic coefficients, time of emptying hemispherical and horizontal cylindrical tank through an orifice at its bottom. Discharge over rectangular, triangular and trapezoidal notches, velocity of approach.

Laminar flow and turbulent flow: Flow of viscous fluid through circular pipe-velocity distribution and average velocity, Hagen-Poiseuille formula, Kinetic energy correction and Momentum Correction factors, Navier-Stokes equation of motion. Reynold's experiment, Loss of head due to friction in pipes, Reynold's expression and Prandtl mixing length theory for turbulent shear stress.

Dimensional and model analysis: Dimensions of fundamental and derived quantities, dimensional homogeneity, Rayleigh's method and Buckingham's π-theorem, similitude, dimensionless numbers, model laws, and classification of models.

Flow through pipes: Major and minor energy losses in pipes, hydraulic gradient and total energy lines, flow through pipes in series, equivalent pipe, flow through parallel pipes, power transmission through pipes and nozzles, and water hammer. Flow in open channels: Uniform flow through open channels using Chezy's formula, most economical sections of channels, non-uniform flow including specific energy and the specific energy curve, critical depth and critical velocity, minimum specific energy, and hydraulic jump.

Text Books:

1. Yunus A. Çengel, *Fluid Mechanics: Fundamentals & Applications (SI Units)*, Tata McGraw- Hill, 4th Edition
2. S. K. Som, G. Biswas, S. Chakraborty, *Introduction to Fluid Mechanics and Fluid Machines*, Tata McGraw Hill Education Private Limited, 3rd Edition

Reference Books:

1. Frank M. White, *Fluid Mechanics*, McGraw-Hill Education, 8th Edition

ME 2305 **3-0-0-3**

Machine Drawing

Prerequisite: Engineering Drawing (ME 1149)

Course Outcomes:

CO1	Identify the national and international standards pertaining to machine drawing.
CO2	Apply limits and tolerances to assemblies and choose appropriate fits.
CO3	Recognize machining and surface finish symbols.
CO4	Explain the functional and manufacturing datum.
CO5	Illustrate various machine components through drawings.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Standardization - Interchangeability - Selective Assembly - Tolerance. Tolerance of form and position - grades of tolerance – limits-fits -Standard tolerances - Machining symbols - surface finish indication – Symbols for weldments, process flow, electrical and instrumentation units.

Introduction to computer aided drafting package to make 2-D drawings. Introduction to solid modellers. Assembly and Part Drawings of simple assemblies and subassemblies of machine parts viz., Shaft Couplings: rigid, flexible: cotter joints, knuckle joints, Hook's joints. Bearings – Journal - Footstep, thrust or Collar bearing; Plummer block; Pulleys for flat belts, V-belt and rope. I.C. Engine components, valves, machine tools, etc.

Engine parts - Stuffing box, Connecting rod, Atomizer, spark plug, fuel injection pump. Valves - stop valve- safety valve, relief valve and non-return valve. Machine tool components - Drill jig, Tail stock, Tool post, Tool head for shaping machine, machine vice, screw jack. Industrial case study drawings in CAD**.**

Text Books:

1. Dhawan, R.K., *A Text Book of Machine Drawing*, S. Chand & Company, 1998, 1st Edition.
2. Ostrowsky, O., *Engineering Drawing with CAD Applications*, Routledge, 1995, 1st Edition.
3. Bhatt, N.D., *Machine Drawing*, Charotar Publishing House, 2003., 38th Edition.

Reference Books:

1. Kannaiah, P., *Production Drawing*, New Age International, 2014., 3rd Edition
2. V. Lakshmi Narayana and M. L. Mathur, *Textbook of Machine Drawing*, M/s Jain Brothers, 2010., 3rd Edition.

ME 2401 **3-0-2-4**

Applied Thermodynamics

Prerequisite: Engineering Thermodynamics (ME 2302)

Course Outcomes:

CO1	Analyze and compare thermodynamic cycles (Carnot, Rankine, Brayton, Otto, Diesel, Dual) for efficiency and applications.
CO2	Explain the working principles of steam/gas turbines and nozzles, including design and performance analysis.
CO3	Demonstrate knowledge of IC engine operation, combustion processes, and performance evaluation methods.
CO4	Evaluate reciprocating compressor performance and propose optimization techniques for minimal work input.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Vapour power cycles: Carnot vapour power cycle, drawbacks as a reference cycle, simple Rankine cycle; description, T-s and P-v diagram,
analysis for performance, comparison of Carnot and Rankine cycles, effects of pressure and temperature on Rankine cycle performance, modified Rankine cycle – reheat Rankine cycle, regenerative Rankine cycle, actual vapour power cycles, open and closed feed water heaters, binary vapour cycles, cogeneration and waste heat recovery.

Steam and gas turbines: Steam nozzles and turbines - supersaturated flow, maximum discharge condition, throat/exit area design, friction effects, classification of steam turbines, velocity diagrams, performance measurement, Brayton cycles, gas turbines - open/closed – reheat, regeneration, intercooling.

IC Engines: Carnot, Otto, diesel and dual cycles and their comparison, IC engines classification, working principle of two-stroke and four-stroke, SI and CI engines, normal and abnormal combustion in SI and CI engines, comparison of ideal and actual air standard cycles (p-v diagram), valve-timing diagram, engine operating characteristics, IC engine performance – heat balance sheet, Morse test, retardation test, fuel properties determination, fuel thermochemistry, air fuel ratio of stochiometric, lean and rich mixtures, exhaust gas analysis.

Reciprocating compressors: Compressor classification, operation of a single stage reciprocating compressors, work input through P-V diagram and steady state steady flow analysis, volumetric efficiency, adiabatic, isothermal and mechanical efficiencies, effect of clearance volume, multistage compressor, saving in work, optimum intermediate pressure, inter-cooling, minimum work for compression.

Text Books:

1. T. D. Eastop and A. McConkey, *Applied Thermodynamics for Engineering Technologists*,Longman Publishing Group, 5th Edition

2. Yunus A. Cengel and Michael A. Boles, *Thermodynamics an engineering approach*, Tata McGraw hill Pub, 6th Edition

Reference Books:

1. P.K. Nag, *Thermal Engineering (Engineering Thermodynamics & Energy Conversion Techniques*, Khanna Publishers, 2014, 5th Edition
2. H. I. H Saravanamuttoo, G. F. C. Rogers and H. Cohen,*Gas Turbine Theory* —Pearson, 5th Edition

ME 2402 **3-0-2-4**

Manufacturing Technology I

Prerequisite:NA

Course Outcomes:

CO1	The student will develop capability of selecting suitable manufacturing processes to manufacture the products optimally. The Students will be able to know the different types of casting processes.
CO2	The student will be able to recommend the appropriate design of gating systems required in casting.
CO3	The Students will be able to know the different types of welding processes and shall be able to understand the advancements in welding techniques and bottlenecks encountered.
CO4	The student will be able to understand the metal forming process and powder metallurgy.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to manufacturing processes: Moulding materials and their requirements; Patterns: Types and various pattern materials. Casting processes: Various casting methods, viz.,

sand casting investment casting, pressure die casting, centrifugal casting, continuous casting, thin roll casting; Mould design; Casting defects and their remedies.

Metal joining processes: brazing, soldering, welding; Solid state welding methods; resistance welding; arc welding; submerged arc welding; inert gas welding; Welding defects, inspection.

Metal forming Processes: Various metal forming techniques and their analysis, viz., forging, rolling, sheet metal working, spinning, swaging, thread rolling; Super plastic deformation; Metal forming defects.

Extrusion: principles, classification, hot extrusion, cold extrusion, load estimation for extrusion, extruding tubes; Wire drawing, Rod and Tube drawing. A brief introduction to Powder metallurgy and its application.

Text Books:

1. A Ghosh and A K Mallik, *Manufacturing Science*, Wiley Eastern, 2nd Edition
2. Dieter, G.E, *Mechanical Metallurgy*, McGraw Hill Education, 2ndEdition

Reference Books:

1. V. Singh, *Physical Metallurgy*, Standard Publishers, 2ndEdition

ME 2403 **3-0-2-4**

Fluid Machinery

Prerequisite: Fluid Mechanics(ME 2304)

Course Outcomes:

CO1	To familiarize oneself with the properties of fluids and the applications of fluid mechanics and fluid machines.
CO2	To formulate and analyze problems related to the calculation of forces in different types of fluid machinery.
CO3	To classify fluid machinery and understand its principles and the behavior of fluid flows.
CO4	To understand the principles of dimensional analysis in fluid machinery.
CO5	To familiarize with the construction and working of turbines and pumps and achieve the knowledge to test their performance.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction - Classification - Dimensional analysis - Specific speed - Basic laws and equations. Hydraulic turbines; Pelton, Francis, and Kaplan turbines - Turbine efficiencies - Cavitation in turbines.

Centrifugal Pumps: theory, components, and characteristics - Cavitation - Axial flow pumps - Pump system matching. Centrifugal and axial flow compressors; slip, surging and choking.

Steam Turbine: impulse and reaction stage, degree of reaction, velocity triangle, velocity and pressure compounding, efficiencies, reheat factor, governing, nozzles - Gas turbine; basic cycle and multi-staging - Power and efficiency calculations. Combustion Chambers; Jet Propulsion

Text Books:

1. S.L Dixon, *Fluid Mechanics and Thermodynamics of Turbomachines*, Butterworth-Heinemann, 2005, 5th Edition
2. A.T Sayers, *Hydraulic and Compressible Flow Turbomachines*, CBLS, 2003, 1st Edition
3. R.K. Bansal, *A Textbook of Fluid Mechanics and Hydraulic Machines*, Lakshmi Publications, 2010, 9th Edition

Reference Books:

1. H.I.H Saravanamuttoo, G.F.C. Rogers and H. Cohen, *Gas Turbine Theory*, Pearson, 4th Ed., 2003
2. F. M. White, *Fluid Mechanics*, Tata McGraw-Hill, 6th Ed., 2008
3. R.W. Fox, A.T. McDonald and P.J. Pritchard, *Introduction to Fluid Mechanics*, John Wiley, 6th Ed., 2004
4. B.R. Munson, D.F. Young, and T.H. Okhiishi, *Fundamentals of Fluid Mechanics*,

Wiley India Edition, 5th Ed., 2002
5. J. D. Anderson (Jr.), *Modern Compressible Flow*, McGraw-Hill, International Ed., 1990
6. Y. A. Cengel and J.M. Cimbala, *Fluid Mechanics*, Tata McGraw-Hill, 2006
7. V Ganesan, *Gas Turbines*, Tata McGraw-Hill, 2nd Ed., 2003

ME 2404 **3-0-0-3**

Kinematics of Machinery

Prerequisite: Engineering Mechanics (ME 1101)

Course Outcomes:

CO1	Understand the principles of kinematic pairs, chains and their classification, degree of freedom, inversions, equivalent chains and planar mechanisms.
CO2	Analyze the planar mechanisms for position, velocity and acceleration.
CO3	Synthesize planar four bar and slider crank mechanisms for specified design requirements.
CO4	Design suitable gears for the given application.
CO5	Synthesize cams and followers for specified motion profiles.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction- Definition of Mechanisms and their classifications, Kinematic inversions, Concept of degree-of-freedom, Grashoff's law -Inversions of slider crank mechanism, Coupler curves, spatial mechanisms, Straight line generators. Slider crank mechanisms and four-bar mechanisms.

Velocity and Acceleration Analysis- Velocities of points on a rigid body, relative velocity, velocity polygon. Acceleration of points on a rigid body, relative acceleration, acceleration polygon. Coriolis acceleration and its applications. Graphical and Analytical methods for the velocity and acceleration analysis of four-bar, slider crank, and other single degree of freedom mechanisms.

Synthesis of Mechanisms- Dimensional synthesis, function generation, path generation and motion generation, Synthesis of single degree freedom closed loop mechanisms for specified

Instantaneous conditions. Identification of the available number of equations, input and output variables, design parameters, and choice of free variables/parameters. Chebyshev spacing for precision positions, Structural error, Overlay method, Complex curve synthesis - Roberts Chebyshev theorem - Frudenstine's equation; Analytical synthesis using complex algebra; synthesis of dwell mechanism.

Gears and Cams: Classification, Terminology, Law of Gearing, Interference and methods to avoid interference in spur gears. Simple, compound, reverted and cycloidal gear trains. Basics of cam and follower mechanisms and their application in various machines.

Text Books:

1. J. J Uicker (Jr), G. R Pennock and J. E Shigley, *Theory of Machines and Mechanisms*, Oxford International Student Edition, 2009, 3rd Edition
2. J. S. Rao, R. V. Dukkipat, *Mechanism and Machine Theory*, New Age International, 2008, 2nd Edition
3. S. S. Rattan, *Theory of Machines*, Tata McGraw Hill, 2016, 5th Edition

Reference Books:

1. A.Ghosh and A. K. Mallik, *Theory of Mechanisms and Machines*, East West Press Pvt. Ltd, 2009, 3rd Edition
2. S. S. Rattan, *Theory of Machines*, Tata McGraw Hill, 2019, 5th Edition
3. R.S. Khurmi and J.K. Gupta, *Theory of Machines*, S. Chand Publishing, 2020, 14th Edition

ME- 2405 **3-0-2-4**

Mechanical Measurements

Prerequisite: NA

Course Outcomes:

CO1	Explain standards, errors, and calibration methods in engineering measurements.
CO2	Apply electrical transducers for measuring force, torque, speed, pressure, and temperature.

CO3	Use metrology tools for length and angle measurements with precision.
CO4	Compare types of comparators and assess their applications and limitations.
CO5	Evaluate surface finish, screw thread, gear measurements, and machine acceptance tests..

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Basics of Measurements: Introduction, Generalized measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction, Dynamic response – zeroth, first and second order measuring systems. Presentation of experimental data: Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis. Calibration - Basic electrical transducers, force, torque, strain, speed, pressure, flow, temperature and heat flux measurement, pollution measurement.

Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers Thermometry: Overview of thermometry, Thermo-electric temperature measurement, Resistance thermometry, Pyrometer, Other methods, issues in measurements.

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, Other methods. Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity and gas composition. Comparators: Their types, relative merits and limitations, use of comparators, construction of Mechanical, electrical & optical comparators.

Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, force, strain Advanced topics: Issues in measuring thermos-physical properties of micro and Nano materials.

Text Books:

1. Holman, J.P., *Experimental Methods for Engineers*, Tata McGraw Hill Book Company, New Delhi, 2010, 10th Edition
2. Thomas G. Beckwith and Lewis Buck, *Mechanical Measurements*, Narosa Publishing House, 2009., 4th Edition

Reference Books:

1. Ernest O. Doeblin, *Measurement Systems - Applications and Design.*, Tata McGraw Hill Book Company, New Delhi, 2011, 4th Edition
2. Jain R K, *Engineering Metrology*, Khanna Publishers, Delhi, 1998, 3rd Edition

ME 3501 **3-1-2-5**

Heat and Mass Transfer

Prerequisite: Applied Thermodynamics (ME2401)

Course Outcomes:

CO1	Understand the basic modes of heat transfer.
CO2	Interpret and compute forced and free convective heat transfer.
CO3	Compute temperature distribution in steady-state and unsteady-state heat conduction.
CO4	Understand and interpret heat transfer through extended surfaces.
CO5	Explain the principles of radiation heat transfer and understand the numerical formula for heat conduction problems. Design heat exchangers using LMTD and NTU methods.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Modes of heat transfer; Conduction: 1-D and 2-D steady conduction; 1-D unsteady conduction- Lumped capacitance and analytical methods.

Fins Convection: fundamentals, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary layers; dimensional analysis; free and forced convection; external and internal flows; heat transfer with phase change.

Radiation: Stefan-Boltzmann law; Planck's law; emissivity and absorptivity; radiant exchange between black surfaces.

Heat exchangers: LMTD and ε-NTU methods; heat transfer enhancement techniques. Mass transfer: molecular diffusion; Fick's law; analogy between heat and mass transfer; evaluation of mass transfer coefficients by dimensional analysis; principles of boiling and condensation.

Text Books:

1. Incropera, F.P. and Dewitt, D.P., *Fundamentals of Heat and Mass Transfer*, John Wiley, 5th Edition, 2002.
2. Holman, J.P., *Heat Transfer,* Tata McGraw-Hill, 9th Edition, 2004.

Reference Books:

1. Ozisik, M.N., *Heat Transfer - A Basic Approach*, McGraw-Hill, 1st Edition, 1985.
2. Cengel, Y.A., *Heat Transfer - A Practical Approach*, McGraw-Hill, 1st Edition, 1998.
3. Bejan, A., *Convective Heat Transfer*, John Wiley and Sons, 3rd Edition, 2004.
4. Kreith, F. and Von (M.S.), *Principles of Heat Transfer,* Brook and Cole Publication, 6th Edition, 2001.

ME 3502 **3-0-2-4**

Manufacturing Technology II

Prerequisite: NA

Course Outcomes:

CO1	Analyze and comprehend the mechanics of metal cutting, tool wear, temperature, and tool life for improved machinability and surface finish.
CO2	Identify and analyze various machine tools and operations such as milling, turning, drilling, and grinding, and their role in modern manufacturing.
CO3	Apply and analyze the design principles of jigs, fixtures, and clamping mechanisms used in batch production and CNC operations.
CO4	Evaluate and synthesize unconventional machining processes and rapid manufacturing techniques for precision and advanced material processing.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Metal Cutting: Mechanics, tools (material, temperature, wear, and life considerations), geometry and chip formation; surface finish and machinability; optimization;

Machine tool: Generation and machining principles; Setting and Operations on machines: lathe, milling (including indexing), shaping, slotting, planing, drilling, boring, broaching, grinding (cylindrical, surface, centreless), thread rolling and gear cutting machines;

Tooling: Jigs and fixtures, principles of location and clamping; Batch production: CNC machines; Finishing: Micro finishing (honing, lapping, super finishing);

Unconventional methods: electro-chemical, electro-discharge, ultrasonic, LASER, electron beam, water jet machining etc.; Rapid prototyping and rapid tooling.

Text Books:

1. A Ghosh and A K Mallik, *Manufacturing Science*, Wiley Eastern, 1986.
2. G K Lal, *Introduction to Machining Science*, New Age International Pvt. Ltd., 2007.

Reference Books:

1. M C Shaw, *Metal Cutting Principles*, MIT Press, 2004.

ME 3503 **3-0-2-4**

Dynamics of Machinery

Prerequisite: EngineeringMechanics(ME1101); Kinematics of Machinery(ME2404)

Course Outcomes:

CO1	Impart knowledge on static and dynamic force analysis of mechanisms.
CO2	Characterize and design flywheels.
CO3	Analyze the balancing of rotating and reciprocating parts in machines as well as analyze centrifugal governors.
CO4	Illustrate the gyroscopic effects in ships, aero planes, and road vehicles.
CO5	Understand free and forced vibrations of single degree freedom systems.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	1	-	1	1	-	2	3	3
CO2	3	2	3	–	2	1	-	1	1	1	2	3	3
CO3	2	3	2	3	3	2	1	1	2	1	3	3	3
CO4	2	2	2	2	2	3	1	1	2	1	2	3	2
CO5	3	3	2	3	3	2	-	1	1	-	3	3	3

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction- Static and dynamic force analysis of mechanisms, flywheel design for systems with prime mover and loading: fluctuation at the prime mover side, fluctuation at the load side, and fluctuation on both sides.

Dynamics analysis and balancing- Dynamic analysis of reciprocating machines; Unbalanced forces and couples in rotating systems. Static and dynamic balancing of single-plane and multi-plane rotating systems. Overview of balancing machines and field balancing. Primary and secondary balancing of single and multi-cylinder inline engines, V-engines, and radial engines.

Governor and Gyroscope- Governors; gravity and spring-controlled governors. Principle of gyroscope, roll, pitch and yaw motions, Gyroscopic effect in aeroplanes, naval ships, automobiles and two wheelers.

Vibrations: Definition of degree of freedoms, free and forced vibrations of single degree of freedom systems, and case studies on rotating/reciprocating unbalances, whirling of rotors.

Text Books:

1. J. J Uicker (Jr), G. R Pennock and J. E Shigley, *Theory of Machines and Mechanisms*, Oxford International Student Edition, 2009, 3rd Edition
2. J. S. Rao, R. V. Dukkipat, *Mechanism and Machine Theory*, New Age International, 2008, 2nd Edition

Reference Books:

1. K. J, Waldron and G. L Kinzel, *Kinematics, Dynamics, and Design of Machinery*, Wiley Student Edition,2004,2nd Edition
2. Ghosh and A. K. Mallik, *Theory of Mechanisms and Machines*, East West Press Pvt. Ltd, 2009, 3rd Edition
3. S.S. Rattan, *Theory of Machines*, Tata McGraw Hill, 2009, 3rd Edition
4. R. L. Norton, *Kinematics and Dynamics of Machinery*, Tata McGraw Hill, 2009, 1st Edition
5. G. Erdman, G. N. Sandor, and Sridhar Kota, *Mechanism Design, Analysis and Synthesis Volume 1*, PHI, Inc., 2001, 4th Edition

ME3504 **3-1-0-4**

Mechanical Vibrations

Prerequisite: NA

Course Outcomes:

CO1	Analyze the causes and effects of vibrations in mechanical systems and identify discrete and continuous systems.
CO2	Model the physical systems into schematic models and formulate the governing equations of motion.
CO3	Compute the free and forced vibration responses of multi-degree of freedom systems through modal analysis and interpret the results.
CO4	Analyse and design systems involving unbalance, transmissibility, vibration isolation, and absorption.
CO5	Analyse and design to control and reduce vibration effects in machinery.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Fundamentals of Vibrations- Introduction to vibrations: Causes, advantages, and disadvantages. Harmonic motion and Fourier series analysis. Elements of vibratory systems and natural frequency determination.

Damped Free Vibrations and Forced Vibrations- Types of damping: Viscous, Coulomb, and structural damping. Logarithmic decrement and frequency of damped vibrations. Critical speed and whirling motion of shafts. Steady-state forced vibrations and resonance.
Transmissibility and vibration isolation. Base excitation and power absorbed by damping.

Two-Degree-of-Freedom Systems and Multi-Degree-of-Freedom Systems- Principal modes of vibration and torsional vibrations. Dynamic vibration absorbers and coordinate coupling. Methods for determining natural frequencies: Rayleigh, Dunkerley, and Stodola. Modal analysis and matrix iteration methods.

Continuous Systems- Vibrations of strings, rods, and beams. Natural frequencies and mode shapes. Approximate methods like Rayleigh-Ritz and Galerkin's method.

Text Books:

1. Meirovitch, Lenord, *Elements of Vibration Analysis*, McGraw Hill Ltd., 2nd Edition (2007).
2. Rao, S.S., Mechanical Vibrations, Pearson Education, 6th Edition (2017).

Reference Books:

1. Thomson, W.T., *Theory of Vibrations with Applications*, Prentice Hall of India, 5th Edition (1999).
2. de Silva, Clarence W., *Vibration: Fundamentals and Practice*, CRC Press, 2nd Edition (2006).

ME 3601 **3-0-0-3**

Design of Machine Elements

Prerequisite: Mechanics of Deformable Bodies (ME 2303)

Course Outcomes:

CO1	Understanding the design function in mechanical engineering, the different steps involved in designing, and the relation of design activity with manufacturing activity.
CO2	Ability to identify and understand failure modes and theories of failures for mechanical elements.
CO3	Capable of designing shafts, keys, and couplings for industrial applications.
CO4	Capable of designing the temporary and permanent type joints in a mechanical system.
CO5	Analyse and design different types of spring and bearings.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction- Mechanical engineering design, Design considerations, Engineering material and its classification, Mechanical properties of engineering materials, Selection of materials, Modes of failure, Theories of failure, Endurance limit, Stress concentration, Notch sensitivity, Factor of safety, S-N Diagram, Goodman and Soderberg criterion.

Theories of failure- Dilation - Distortion - Maximum Principal Stress Theory - Maximum Principal Strain Theory - Maximum Shear Stress Theory - Strain Energy Theory - Distortion energy theory.

Shafts and Couplings -Design of solid and hollow shafts based on strength and rigidity, Keys, keyways, and splines, Design of rigid and flexible couplings.

Temporary and Permanent Joints- Design of cotter and knuckle joints, Design of welded joints - Fillet and butt welds, Design of riveted joints, Rivet heads, Terminology, Caulking and fullering, Analysis of riveted joint, Efficiency of a riveted joint, Design of boiler joints and structural joints, merits and demerits of welded joint over riveted joints, Strength of parallel and fillet weld, Weld subject to bending moment and torsional moment, Problems.

Springs and Bearings- Types of springs, spring materials, terminology, spring in series and parallel, axial load and torque on helical springs, stresses and deformations, strain energy stored in springs, compound springs, leaf springs, Introduction to bearings and its classification, Design of sliding contact bearings, Selection of rolling contact bearings.

Text Books:

1. Richard G. Budynas, J Keith Nisbett, Shigley's, *Mechanical Engineering Design*, McGraw Hill Ltd. 2011, 9th Edition
2. V B Bhandari, *Design of Machine Elements*, McGraw Hill Ltd. 2012, 3rd Edition

Reference Books:

1. Robert L Norton, *Machine design an integrated approach*, Pearson Education, 2009, 2nd Edition
2. S G Kulkarni, *Machine Design*, Tata McGraw Hill, New Delhi, 2008

ME 3602 **3-1-2-5**

Mechatronics and Robotics

Prerequisite: NA

Course Outcomes:

CO1	Explain the fundamentals of mechatronic systems by integrating mechanical, electrical, electronic, and computer engineering concepts.
CO2	Analyze sensors, actuators, and transducers for measurement and control applications in automated systems.
CO3	Develop and debug embedded systems using microcontrollers and programming languages like C for real-time control applications.
CO4	Design and simulate basic mechatronic systems using principles of PLCs, SCADA, and robotics tools.
CO5	Demonstrate problem-solving skills and teamwork through practical experiments, projects, and case studies in industrial automation and robotics.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Introduction to Mechatronics-Systems-Measurement Systems- Control Systems Mechatronics Approach.

Sensors and Transducers: Introduction-Performance, Terminology Displacement, Position and Proximity-Velocity and Motion Fluid Pressure-Temperature Sensors-Light Sensors-Selection of Sensors-Signal Processing. 8085

Microprocessor: Introduction Architecture-Pin Configuration-Instruction set- Programming of Microprocessors using 8085 instructions-Interfacing input and output devices-Interfacing D/A converters and A/D converters Applications- Temperature control- Stepper motor control-Traffic light controller. PROGRAMMABLE LOGIC CONTROLLERS: Introduction-Basic structure-Input/Output Processing-Programming Mnemonics-Timers, Internal relays and counters-Data handling-Analog Input/Output-Selection of a PLC..

Design and Mechatronics: Stages in Designing mechatronic systems - Traditional and Mechatronic design -Possible design solutions-Case studies of mechatronic systems - Pick and place robot - automatic car park system -engine management system.

Introduction To Industrial Robotics: Classification of Robot Configurations, functional line diagram, degrees of freedom, common types of arms, joints and grippers, factors to be considered in the design of grippers.

Robot actuators and feedback components: Actuators, Pneumatic and hydraulic actuators, Electric and Stepper motors, Position sensors – potentiometers, resolvers, encoders – velocity

sensors, Tactile sensors, Proximity sensors

Manipulator kinematics: Homogeneous transformations, DH notation, Forward and inverse kinematics.

Manipulator dynamics: Differential transformations, Jacobians, Lagrange-Euler and Newton-Euler formulations, Trajectory planning, obstacle avoidance and path planning, skew motion, joint integrated motion – straight line motion.

Text Books:

1. Longman, W. Bolton, *Mechatronics*, Addison Wesley Longman Ltd., 1999, 2nd Edition
2. Alciatore David G and Histand Michael B, *Introduction to Mechatronics and Measurement systems,* Tata McGraw Hill, 2012, 4th Edition.
3. Mikell P. Groover, *Industrial Robotics*, McGraw-Hill Education, 1st Edition, 1987

Reference Books:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson Prentice Hall, 3rd Edition
2. Clarence W. de Silva, *Mechatronics: A foundation course*, CRC Press, 2010., 1st Edition
3. Devdas Shetty and Richard, A. K., Vikas, *Mechatronics System Design*, Publishing House Private Ltd., 2002., 1st Edition

ME 3603 **3-0-2-4**

Automobile Engineering

Prerequisite: NA

Course Outcomes:

CO1	To enable students to understand the functions of various components/subassemblies of automobiles.
CO2	To apply engineering design principles for designing the components of Automobiles.
CO3	Understand recent trends in alternative fuels, pollution control and safety systems.
CO4	Evaluation of the functionality of suspension, steering, braking and transmission systems.
CO5	Technology development for special vehicle like, sport car, earth mover etc.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Fuels and fuel systems: general introduction. SI Engines fuel injection systems: Requirement and need for fuel injection. Classification of systems in practice. MPFI system operation, construction, and working of important sensors used in FI injection system. CI Engine fuel injection systems: Requirement of Diesel injection systems.
Classification–injectors for CI Engines, alternate fuels for CI engines.

Engine induction and Exhaust Systems: Requirements and considerations. Manifold flowpaths and tuning. Introduction to exhaust gas extraction. Turbocharging, types, variable geometry turbocharger.

Engine valve operating systems: Effect of Valve timing and valve lift on engine operation; variable valve lift and variable valve timing. Valve operating conditions. Multi valve engines. General: Development S Advances in Automobile engineering.

Engine types- advanced engine systems: Ignition systems for petrol engines. Advanced cooling concepts, radiators, and thermostat. Windshield wiper fuel gauge. Chassis and suspension: Requirements and general consideration of strength and stiffness. Engine mountings, types of suspension.

Transmission: Clutch, types, fluid flywheel, torque converter, gear boxes, universal joint, propeller shaft, differential, rear axles and their types, front axles and their types.
Steering: Factor controlling rolling and directional stability, castor angle, wheel camber, steering geometry and system, power assisted steering.

Brakes: Principle of braking system, braking mechanism, mechanical and hydraulic brakes, power brakes, vacuum and air brakes. Wheels and Tyres: Wheel drum, tyre, materials and manufacturing of tyres, trouble shooting and maintenance and safety.

Text Books:

1. N. K. Giri, *Automobile Mechanics,* Khanna Publishers, 5th Edition, 2014.
2. R. K. Rajput, *Automobile Engineering*, Laxmi Publications, 1st Edition, 2008.
3. Dr. Kirpal Singh, *Automobile Engineering,* Standard Publishers, New Delhi, 13th Edition (Vol. 1 S 2), 2020.
4. K.V. Fadadu and B.H. Kadiya, *Vehicle Testing And Homologation,* Books India Publications, 1st Edition, 2016.
5. R. B. Gupta, *Automobile Engineering*, Satya Publishers, 7th Edition, 2016.
6. GBS Narang, *Automobile Engineering,* Khanna Publishers, 5th Edition, 1995.

Reference Books:

1. Robert Bosch, *Bosch Automotive Handbook,* Wiley Publications, 10th Edition, 2018.
2. James D. Halderman, *Automotive Chassis Systems*, Pearson Publishers, 7th Edition, 2016.
3. Jack Erjavec, Martin Restoule, Stephen Leroux, Rob D. Thompson, *Automotive Technology - A Systems Approach*, Nelson Education Limited, 3rd Edition, 2015.
4. James E. Duffy, *Modern Automotive Technology*, Goodheart-Willcox, 8th Edition, 2013.

ME 3604 **3-0-0-3**

Refrigeration and Air Conditioning

Prerequisite: ME 2302 - Engineering Thermodynamics

Course Outcomes:

CO1	Explain fundamental thermodynamic concepts, refrigeration principles, and the working of heat engines, refrigerators, and heat pumps.
CO2	Analyze the limitations of reversed Carnot cycles and evaluate the performance of Bell-Coleman and air cycle refrigeration systems.
CO3	Examine vapour compression refrigeration systems (VCRS), including modifications and compare vapour absorption refrigeration systems (VARS) with VCRS and assess working principles of aqua-ammonia and LiBr-water systems.
CO4	Classify and assess the performance of refrigeration system components such as compressors, condensers, evaporators, and expansion devices.
CO5	Interpret psychrometric charts, analyze air-conditioning processes, and perform cooling load calculations for comfort and industrial applications.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Review of thermodynamics: system, state, properties, process, heat, work, first and second laws, saturation pressure temperature relationship, heat engine, refrigerator, heat pump, Carnot cycle, reversed Carnot cycle, history of refrigeration and air conditioning, definitions of various terms, methods of refrigeration.

Air refrigeration system: Limitations of reversed Carnot cycle, Bell-Coleman cycle and its analysis, necessity of aircraft refrigeration – air cycle refrigeration systems and their comparison.

Vapour compression refrigeration systems: Modifications in reversed Carnot cycle, standard vapour compression refrigeration cycle (VCRS), superheat horn and throttling losses, superheating and subcooling in VCRS, Analysis of Vapour compression cycle, multi-stage VCRS – multi-pressure systems, multi-evaporator systems, cascade systems, Properties of refrigerants.

Vapour absorption refrigeration systems: Principle of absorption system; components of the system, desirable properties of absorption system refrigerant and absorbent, aqua–ammonia absorption refrigeration system, lithium bromide–water absorption refrigeration system, comparison between absorption and compression system.

Refrigeration system components Classifications of compressors, performance characteristics of reciprocating compressors, classifications of evaporators S condensers and their characteristics, expansion devices – capillary tube and thermostatic expansion valves. (05 Hours)

Psychrometry and air-conditioning systems: Psychrometric properties, preparation of

psychrometric charts, psychrometric processes, bypass factor, apparatus dew point, sensible heat factor, air washer, evaporative cooling, adiabatic humidification, efficiency of humidification, summer and winter air conditioning system, load calculations, comfort conditions, applications with specified ventilation air quantity, use of RSHF, ERSHF and GRSHF.

Text Books:

1. Arora, C. P., *Refrigeration and Air-Conditioning*, McGraw Hill, 4th Edition.
2. Dossat, R. J., *Principles of Refrigeration*, Pearson Education India, 4th Edition.

Reference Books:

1. Stoecker, W. F. and Jones, J. W., *Refrigeration and Air Conditioning*, McGraw Hill, 2nd Edition.
2. Prasad, M., *Refrigeration and Air Conditioning*, New Age International Publishers, 3rd Edition.

ME 4702 **3-0-2-4**

CAD/CAM

Prerequisite: NA

Course Outcomes:

CO1	Understand and analyze the hardware configuration and peripherals required for CAD applications and explain the basics of computer graphics including 2D/3D transformations and projections.
CO2	Recall and analyze different curve and surface modeling techniques such as plane curves, space curves, and solid modeling, including hidden line algorithms.
CO3	Apply and analyze the use of CAD/CAM software tools like AutoCAD, PRO ENGINEER, and ANSYS for part modeling, simulation, and engineering drawing creation.
CO4	Synthesize and evaluate NC programming concepts, including G & M codes, APT language, and parametric programming, and assess the implementation of CAPP and Flexible Manufacturing Systems.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Principles of Computer Aided Design (CAD): Computer configuration for CAD applications, Computer peripherals for CAD. Fundamentals of Computer Graphics: Two- dimensional transformation, three-dimensional transformation and projections.

Plane Curves and Space Curves: Surface description and generation. Hidden line algorithms for wire frame modelling. Solid modelling. Introduction to Computer Aided Drafting and Analysis Software's such Auto CAD, PRO ENGINEER, ANSYS, etc. CAD System utilization and application.

Computer Aided Manufacturing (CAM): Introduction; Numerical control of machine tools, nomenclature, types, features, MCU. Transducers: Tooling for N.C. Machines, ISO G & M Codes, N.C. part programming, tool setting, cutter compensation, parametric programming, APT language structure, APT Geometry, motion commands, post processor commands, repetitive programming, compilation and control commands.

Introduction to Computer Aided Process Planning: Introduction to Flexible Manufacturing Systems.

Text Books:

1. Ibrahim Zeid and Sivasubramanian, R., *CAD/CAM Theory and Practice*, McGraw Hill Education, 2009.
2. Yoram Koren, *Computer Control of Manufacturing Systems*, McGraw Hill Student edition, 2005.

Reference Books:

1. Rao, P.N., *CAD / CAM Principles and Applications*, McGraw Hill Publishers, 2010.

Syllabus of Departmental Elective I Courses

ME 3571 **3-0-0-3**

AI and ML in Mechanical Engineering

Prerequisite: NA

Course Outcomes:

CO1	Analyze the causes and effects of vibrations in mechanical systems and identify discrete and continuous systems.
CO2	Model the physical systems into schematic models and formulate the governing equations of motion.
CO3	Compute the free and forced vibration responses of multi-degree of freedom systems through modal analysis and interpret the results.
CO4	Analyse and design systems involving unbalance, transmissibility, vibration isolation, and absorption.
CO5	Analyse and design to control and reduce vibration effects in machinery.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Basics of Engineering Design and Statistics - Introduction to Statistics – descriptive statistics, dispersion measures, central tendency measures, hypothesis testing, inferential statistics, correlation and regression, p-value, central limit theorem, feature engineering.

Machine Learning Algorithms - Basics of AI, ML, & DL. Fundamentals of ML - supervised, unsupervised, reinforcement learning. Supervised machine learning – Regression: linear regression, multi-linear regression, non-linear regression, logistic regression. Classification: neural networks, decision trees, random forests, support vector machine, k-nearest neighbor.

Unsupervised machine learning – mixture models, hierarchical k-means clustering, principal component analysis.
Deep Learning Algorithms – Perceptron, Deep feedforward neural nets, Convolutional neural networks, Long short-term memory (LSTM) networks. Introduction to Graph Neural networks, Generative Adversarial Networks, and Reinforcement Learning.

Python for Machine Learning - Getting started with Python, Basic Commands, working with Python libraries, Loops, Variables, Data types, and Data visualization, exploring AI through python- neural networks and machine learning in python.

Applications - SHM Paradigm, feature extraction, feature importance, correlation, and eigenvalue analyses, feature augmentation, performance and validation of ML/DL models in mechanical engineering applications.

Text Books:

1. Thomas Nield, *Essential Math for Data Science,* O' Reilly Media, 1st Edition

Reference Books:

1. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems,* Shroff/O'Reilly, 3rd Edition
2. Gopinath Rebala, Ajay Ravi, Sanjay Churiwala, *An Introduction to Machine Learning,* Springer Cham, 1st Edition

ME 3572 **3-0-0-3**

Introduction to Two Phase Flow

Prerequisite: Fluid Mechanics (ME 2304)

Course Outcomes:

CO1	Understand the concept of two-phase flow, its different types (e.g., gas-liquid, liquid-liquid, solid-liquid), and the relevant terminology.
CO2	Identify and understand different flow patterns in two-phase flow.
CO3	Learn different correlations for pressure drop and void fractions.
CO4	Study various flow regimes of boiling.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Formulation and Solution to Phase Change Problem, Two Phase Flow Fundamentals.
Review of one-dimensional conservation equations in single-phase flows.
Governing equations for homogeneous, separated and drift-flux model; Flow pattern maps for horizontal and vertical systems.
Simplified treatment of stratified, bubbly, slug and annular flows.

Text Books:

1. C. Kleinstreuer, Two-Phase Flow: Theory and Applications, Taylor & Francis, 2003, 1st Edition

Reference Books:

1. J.G. Collier and J.R. Thome, *Convective Boiling and Condensation*, Oxford University Press, 1996, 3rd Edition
2. G.B. Wallis, *One-Dimensional Two-Phase Flow*, McGraw-Hill, 1969, 1st Edition
3. P B Whalley, *Boiling, Condensation and Gas-Liquid Flow*, Oxford University Press, 1987, 1st Edition
4. S. Tong and Y.S. Tang, *Boiling Heat Transfer and Two-Phase Flow*, Taylor and Francis, 1997, 2nd Edition
5. M. Ishii and T. Hibiki, *Thermo-Fluid Dynamics of Two-Phase Flow*, Springer, 2006, 1st Edition

ME 3573 **3-0-0-3**

Introduction to Turbulent Flow

Prerequisite: Fluid Mechanics (ME 2304)

Course Outcomes:

CO1	Identify and understand various turbulence models and their limitations.

CO2	Understand the fundamental concepts of fluid mechanics and turbulence.
CO3	Apply statistical methods to analyze turbulent flows.
CO4	Predict and simulate turbulent flows using numerical methods

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Transition from laminar to turbulence, nature of turbulence and irregularity, types of turbulent flows, three-dimensional motions.
Statistical Description of Turbulence, Kolmogorov hypothesis, turbulence spectra.
Introduction to turbulence modelling and experimental method.

Text Books:

1. Incropera, F.P. and Dewitt, D.P., *Fundamentals of Heat and Mass Transfer*, John Wiley, 5th Edition, 2002.
2. Holman, J.P., *Heat Transfer*, Tata McGraw-Hill, 9th Edition, 2004.

Reference Books:

1. Pope, S.B., *Turbulent Flows*, Cambridge University Press, 1st Edition, 2000.
2. Anderson, J.D., *Modern Compressible Flow*, McGraw Hill, 1st Edition, 1989.
3. Davidson, P.A., *The Dynamics and Thermodynamics of Compressible Flow*, The Ronald Press Co., 1st Edition, 1954.
4. Biswas, G. and Eswaran, V., *Turbulent Flows: Fundamentals, Experiments and Modeling*, Narosa Publishing House, 1st Edition, 2002.
5. Garde, R.J., *Turbulent Flow*, New Age International Publishers, 1st Edition, 2000.
6. Sagaut, P. and Cambon, C., *Homogeneous Turbulence Dynamics*, Cambridge University Press, 1st Edition, 2008.
7. Tennekes, H. and Lumley, J.L., *A First Course in Turbulence*, The MIT Press, 1972.

ME 3574 **3-0-0-3**

Advanced Solid Mechanics

Prerequisite: Mechanics of Deformable Bodies (ME 2303)

Course Outcomes:

CO1	To get familiar with the mathematical preliminaries.
CO2	To understand the concept of stress and equilibrium.
CO3	To understand the measure of deformation and the compatibility conditions.
CO4	To understand the elastic constitutive relations.
CO5	To solve and understand the solutions of boundary value problems in classical elasticity.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Introduction, Conceptual foundations, Mathematical preliminaries .

Stress and Strain: Stress field (Traction, Cauchy's principle, Stress tensor, Equilibrium equations, Principal stresses).

Strain: Kinematics of deformable bodies (Strain tensor, Compatibility) .

Constitutive relations: Constitutive relations (1D and 3D elasticity, thermo-mechanical relations).

Boundary Value Problems in Elasticity: Boundary value problems in elasticity (Uniqueness, Principle of super position, Plane stress/strain, Airy stress function and examples, Torsion of noncircular bars).

Text Books:

1. L. S. Srinath, *Advanced mechanics of solids*, McGraw Hill Education, 3rd Edition
2. T. G. Sitharam, L. Govindaraju, *Theory of Elasticity*, Springer Singapore, 1st Edition

Reference Books:

1. S. P. Timoshenko and J. N. Goodier, *Theory of Elasticity*, McGraw Hill Education, 3rd Edition

ME 3575 **3-0-0-3**

Non-Destructive Testing

Prerequisite: NA

Course outcomes:

CO1	To understand the fundamental aspects and applications of non-destructive testing.
CO2	To understand the ultrasonic based techniques in NDT.
CO3	To understand thermography techniques in NDT.
CO4	To understand the radiography and its application in defect detections.
CO5	To understand the eddy current based techniques in identifying defects.
CO6	To understand the different acoustic emission and magnetic particle based inspection techniques in identifying defects.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to NDT - Liquid penetrant test: Physical principles, procedure for penetrant testing, penetrant testing materials, penetrant testing methods, sensitivity, applications and limitations, typical examples.

Ultrasonic testing - Basic properties of sound beam, ultrasonic transducers, inspection methods, techniques for normal beam inspection, techniques for angle beam inspection, flaw characterization techniques, applications of ultrasonic testing, advantages and limitations.
Thermography - Basic principles, detectors and equipment, techniques, applications.

Radiography - Basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations, typical examples.

Eddy current test - Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy current test methods, applications, limitations.

Acoustic emission and Magnetic particle inspection - Principle of AET, technique, instrumentation, sensitivity, applications; acoustic emission technique for leak detection. Principle of MPT, procedure used for testing a component, sensitivity, limitations.

Text Books:

1. Baldev Raj, M. Thavasimuthu, and T. Jayakumar, *Practical Non-Destructive Testing*, Narosa Publishing House, 3rd Edition.

Reference Books:

1. Peter J. Shull, *Nondestructive Evaluation: Theory, Techniques and Applications*, CRC Press, 1st Edition.
2. Aquil Ahmad and Leonard J. Bond, *ASM Handbook: Non Destructive Testing and Quality Control*, ASM International , 1st Edition.

ME 3576 **3-0-0-3**

Elements of Plastic Technology

Prerequisite: NA

Course Outcomes:

CO1	Analyze effect of processing variables on the product quality in injection, compression molding and extrusion process.
CO2	Evaluate effect of various design parameters on plastic processing.
CO3	Select suitable material for moulds used in the plastic industry.
CO4	Ability to test the plastics materials for its chemical, mechanical, electrical, optical, thermal, and permanence properties as per the standard.
CO5	Ability to identify the plastic materials by reverse engineering for some specified applications with the knowledge of testing.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Manufacturing Technologies for Thermoplastics- Unit Operations in Plastic Materials Manufacture; Manufacture of Commodity plastic materials.

Plastics Processing Techniques: Injection Molding: process, Extrusion: process, Blow Molding: process, Thermoforming:process, Compression Molding: process.

Manufacture of Engineering Thermoplastic Materials: Manufacture with plant layout for Nylon-6, / 66 resins, PEEK, PPS, PC, Acetal Copolymers, PET, PTFE, etc. Applications, Advantages, and Disadvantages of each resin.

Testing and Characterization of Plastics: Mechanical testing: tensile, flexural, impact, hardness ASTM standards, Thermal analysis: DSC, TGA, DMA, Spectroscopic techniques: FTIR, NMR, Application in polymer identification

Environmental Aspects and Future Trends: Plastics recycling and waste management strategies, Chemical vs. Mechanical recycling techniques, Biodegradable and bio-based polymers, Market trends in bio-plastics, Emerging trends in plastic technology: nano-composites, 3D printing.

Text Books:

1. Randolph Norris Shreve and George T. Austin, *Shreve's Chemical Process Industries*, McGraw Hill Education, 2017, 5th Edition
2. J. A. Brydson, *Plastic Materials*, ButterWorth Heinemann, 1999, 7th Edition
3. Roger P. Brown, *Testing & Recycling of Plastics*, CBS Publishers and distributors, 2004, 2nd Edition

Reference Books:

1. Brown; Paul F (Ed), *Hand Book of Plastics Test Methods*, Longman Scientific and Technical, Harlow, 1st Edition, 1988
2. Blythe, A. R., *Electrical Properties of Polymers*, Cambridge University Press, 2005, 2nd Edition

ME3577 **3-0-0-3**

Acoustics

Prerequisite: NA

Course Outcomes:

CO1	An understanding of the sound waves
CO2	To be able to analyze the mathematical modeling aspects of sound waves
CO3	Basic understanding of the terminologies in acoustics
CO4	To understand the importance of impedance in sound wave propagation
CO5	To understand sound wave propagation in waveguides

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to wave phenomenon: Introduction, Terminology, Forward and backward propagating pulse, Sound or wave speed.

Development of one-dimensional acoustic wave equation: Derivation of continuity and momentum equation based on control volume approach, Isentropic (State) relationship, Acoustic state variables: perturbation pressure, density and velocity, Planar wave fronts in an infinite waveguide, D-Alembert's solution, Helmholtz equation (frequency-domain), Backward and Forward propagating waves, Boundary conditions: rigid, open and impedance conditions, Resonance frequencies of an open or a closed duct, 1- D acoustic waves in an infinite duct with a uniform moving medium.

Acoustic Terminology (Measurement Units): Acoustic pressure, velocity, density (revise), Impedance, Acoustic power expression, Sound Pressure Level (SPL), Sound Intensity Level, Sound Power Level, Spectrum and Frequency bands.

Reflection and Transmission of Normally Incident Plane waves: Reflection and Transmission coefficients, Reflection of plane wave at infinite plane boundary, special cases of rigid-wall (termination), pressure release, matched-impedance conditions, general resistive or impedance termination, Reflection at finite interface: change in cross-sectional area, Rayleigh Sommerfeld radiation formulation.

Wave propagation in waveguides: Waveguides of rectangular, circular cylindrical geometry: Solution of Helmholtz equation in Cartesian and cylindrical polar co-ordinates, normal (rigid-wall) modes and natural frequencies, cut-on and cut-off frequencies, evanescent modes, Gradually varying area ducts: Webster's horn equation, Ducts with compliant walls.

Text Books:

1. Lawrence E. Kinsler, Austin R. Frey, Alan B. Coppens, James V. Sanders, *Fundamentals of Acoustics*, John Wiley and Sons, 4th Edition

Reference Books:

1. Philip M. Morse and Uno Ingard, *Theoretical Acoustics*, Princeton University Press, 1st Edition, 1986
2. David T. Blackstock, *Fundamentals of Physical Acoustics*, John Wiley, 1st Edition, 2000

ME 3578 **3-0-0-3**

Tribology

Prerequisite: NA

Course Outcomes:

CO1	Grasp the basics of tribology and associated parameters.
CO2	Utilize tribological principles to evaluate the performance and guide the design of components subjected to relative motion.
CO3	Analyse and evaluate the characteristics of surfaces to forecast their tribological behavior.
CO4	Recognise the lubrication regime for various mechanical applications.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction- Lubricants: Definitions, Classifications, and their engineering applications. Characteristics and selection of lubricants, viscosity and its measurement, effect of temperature and pressure on viscosity, types of lubrication, and standard grades of lubricants.

Friction and Wear- Theories of friction, Measurement methods, and factors affecting friction. Types of wear: adhesive, abrasive, corrosive, fatigue, etc., mechanisms and measurement of wear. Delamination theory, debris analysis, testing methods, and standards. Friction and wear mechanisms for metals, polymers, and ceramics.
Surface modification and coating techniques- Concept and scope of surface engineering. Surface modification – transformation hardening, surface melting, thermo chemical processes. Surface Coating - plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.

Bearings and recent advancements in the tribology- Definition of bearing, classification, and applications. Hydrodynamic and hydrostatic bearings. Gas-lubricated bearings and their design. Ball Bearings and Roller Bearings. Nano-tribology and bio-tribology. Tribological testing and analysis.

Text Books:

1. Stachowaik, G.W. and Batchelor, A.W., *Engineering Tribology*, Elsevier, 3rd Edition
2. B. Bhushan, *Introduction to Tribology*, John Wiley & Sons, Inc., New York, 2nd Edition

Reference Books:

1. A Cameron and C.M. Mc Ettles, *Basic Lubrication Theory*, 1987, Wiley Eastern Ltd., New Delhi

Syllabus of Departmental Elective II Courses

ME 3671 **3-0-0-3**

Theory of Microfluids

Prerequisite: Fluid Mechanics (ME 2304)

Course Outcomes:

CO1	To gain an understanding of the fundamental theories of microfluidics.
CO2	To be able to describe the various microfabrication techniques.
CO3	To be able to analyse and solve problems on fluid flow at microscale level using appropriate mathematical tools.
CO4	To be able to identify and evaluate the diverse applications of microfluidics.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Brief history, Present scope, Fundamental Fluid Mechanics Principles (Continuum vs Molecular Theory, Newtonian and non-Newtonian fluids), Scaling Laws, Materials for Microfluidic Devices (Polymers, glass, silicon, and their properties).

Microfluidic Fluid Flow: Governing Equations of Microfluidics (Navier-Stokes equations for microscale flows, Boundary layer theory in microchannels), Electrokinetic Phenomena (Electroosmosis, electrophoresis, and Di electrophoresis), Capillary Effects (Surface tension, wetting, and capillary action in microchannels).

Microfluidic Components and Systems: Microvalves, Micropumps, Micromixers, Lab-on-a-chip, Fabrication Methods (Photolithography, soft lithography, and 3D printing).

Applications: Biomedical Applications, Chemical Analysis, Environmental Applications, Future Trends and Innovations.

Text Books:

1. Paul Tabeling, *Introduction to microfluidics*, , Oxford University Press, 2nd Edition.

Reference Books:

1. Pingan Zhu, Liqiu Wang, *Microfluidics-Enabled Soft Manufacture*, Springer International Publishing, 1st Edition.
2. Andreas Manz, Pavel Neužil, Jonathan S O'Connor, Giuseppina Simone, *Microfluidics and Lab-on-a-chip*, Royal Society of Chemistry, 1st Edition.

ME 3672 **3-0-0-3**

Materials Handling

Prerequisite: None

Course Outcomes:

CO1	Understand the procedures for systematic integration of organization.
CO2	Learn various techniques and tools of layout planning.
CO3	Get knowledge of various industrial layouts.
CO4	Understand the material handling systems.
CO5	Learn the concept of industrial building and industrial utilities.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Objectives of Facility Design: Types of layout problems, the layout function; organization of layout: Product, process, Group Layout. Process design, product analysis, Computerized process planning. Elements of Material Handling System; Selection of Material Handling Equipment's; Design of Mechanical Handling Equipments; Design of Hoists Design of Cranes.

Analysis and design of Material flow: Systems approach to flow cycle, flow possibilities, facility layout, process charts, string diagram, flow process chart; quantitative analysis of material flow; line balancing techniques, optimal material flow configuration. Space and area allocation for production and physical plant service; Computerized handling of layout algorithms.

Introduction to various Mechanical Handling Systems and equipment for handling unit load and bulk materials: pulley blocks, winches, electric hoists, EOT cranes, belt conveyor, Bucket elevator, Screw conveyor and pneumatic conveyor.

Kinematic analysis and design procedures of their component mechanisms: Design concept of warehouse facilities commensurate with adopted kind of handling and transfer devices; Concepts of AGVs, AS/RS and other automated materials handling devices. Automated packaging devices; design of Integrated Plant Layout for Product Handling Systems. Safety and design; Safety regulations and discipline.

Text Books:

1. S. C. Sharma, *Plant layout and material handling*, Khanna publishers, 2015, 3rd Edition.
2. James M. Apple, *Plant Layout and Material Handling*, John Wiley & Sons, 1977, 3rd Edition.

Reference Books:

1. T.H. Allegri, *Materials Handling (Principles & Practice)*, CBS, 1984, 1st Edition.
2. James M. Apple, *Material Handling Systems Design*, John Wiley & Sons, 1977, 1st Edition.

ME 3673 **3-0-0-3**

Introduction to Combustion Engineering

Prerequisite: Applied Thermodynamics (ME 2401), Heat and Mass Transfer (ME3501)

Course Outcomes:

CO1	Explain combustion fundamentals, flame types, and thermochemical principles.
CO2	Apply mass transfer and chemical kinetics concepts to combustion processes.
CO3	Analyze chemical mechanisms and ideal reacting systems.
CO4	Formulate conservation equations for reacting flows and describe laminar premixed flames.
CO5	Describe laminar diffusion flames and evaluate combustion emissions.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Fundamentals of Combustion and Thermochemistry: - Combustion modes and flame types, property relations, first law of thermodynamics, reactant and product mixtures, adiabatic flame temperature, chemical equilibrium, equilibrium products of combustion.

Mass Transfer and Chemical Kinetics: - Introduction to mass transfer, mass transfer rate laws, species conservation, the Stefan problem, liquid-vapor interface boundary conditions, droplet evaporation, global versus elementary reactions, elementary reaction rates, rates of reaction for multistep mechanisms.

Key Chemical Mechanisms and Reacting Systems: - Important chemical mechanisms: H_2-O_2 system, carbon monoxide oxidation, oxidation of higher paraffins, methane combustion, oxides of nitrogen; coupling chemical and thermal analysis of reacting systems: constant-pressure fixed mass reactor, constant-volume fixed mass reactor, well-stirred reactor, plug-flow reactor**.**

Conservation Equations and Laminar Flames: - Conservation equations for reacting flows: overall mass conservation, species conservation, multicomponent diffusion, momentum conservation, energy conservation, the concept of a conserved scalar; laminar premixed flames: physical description, simplified and detailed analysis, flame velocity and thickness, quenching, flammability, ignition, and flame stabilization.

Diffusion Flames and Emissions: - Laminar diffusion flames: nonreacting constant density laminar jet, jet flame physical description, simplified theoretical descriptions, soot formation and destruction, counter flow flames; pollution emissions: effects of pollutants, quantification of emissions, emissions from premixed and nonpremixed combustion.

Text Books:

1. S. R. Turns, *An Introduction to Combustion*, McGraw Hill, 2nd Edition.
2. J. Warnatz, U. Mass and R. W. Dibble, *Combustion*, Springer, 3rd Edition.

Reference Books:

1. F. A Wiiliams, *Combustion Theory*, Addison Wesley Publishing Company, 2nd Edition.

ME 3674 **3-0-0-3**

Energy Conservation and Waste Heat Recovery

Prerequisite: Fluid Mechanics (ME 2304), Heat and Mass Transfer (ME 3501).

Course Outcomes:

CO1	Understand various energy resources, their industrial applications, and the importance of energy conservation, audits, and cogeneration systems.
CO2	Evaluate energy systems using exergy and availability analysis, and identify suitable waste heat recovery methods for improving thermal efficiency.
CO3	Analyze and compare advanced heat recovery systems including heat pipes, thermoelectric systems, and heat pumps for diverse industrial and HVAC applications.
CO4	Identify and assess suitable energy storage techniques and interpret energy economics for sustainable energy management in engineering systems.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	2	3	-	-	-	-	-	-	3	3
CO2	3	2	3	2	3	-	-	-	-	-	-	3	3
CO3	3	2	3	2	3	-	-	-	-	-	-	3	3
CO4	3	2	3	2	3	-	-	-	-	-	-	3	3

1 – Low **2 – Medium** **3 – High**

Details Syllabus:

Energy resources and their use in industry and transportation. Potential and need for energy conservation. Principles of energy audit. Energy-intensive processes and industries. Optimal utilization of fossil fuels. Total energy systems. Coupled cycles and combined plants. Fundamentals of cogeneration and its applications.

Exergy and availability analysis. Thermodynamic evaluation of systems for energy efficiency. Industrial waste heat sources and characteristics. Waste heat recovery equipment: Recuperators, regenerators, heat exchangers (shell & tube, spiral tube, plate type), waste heat boilers.

Heat pipe technology, fluidized bed heat recovery, thermoelectric systems, and heat pumps. Applications in HVAC and refrigeration systems. Energy recovery from incineration plants and reject heat from power plants. Low-grade heat utilization.

Energy Storage Techniques – Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic storage; Energy Storage Techniques – Thermal storage (Sensible & Latent), Battery, Chemical Energy Storage, Fuel cells. Energy Economics.

Text Books:

1. J. H. Harlock, *Combined Heat and Power*, Pergaman Press, 1st Edition.
2. T. L. Boyen, *Thermal Energy Recovery*, Wiley Eastern, 1st Edition.

Reference Books:

1. F. Kreith and R. E. *West, Energy Efficiency*, CRC Press, 2nd Edition.

ME 3675 **3-0-0-3**

Composite Materials

Prerequisite: None

Course Outcomes:

CO1	Apply knowledge of Metals, Composites, their science and engineering involved, and different fabrication methods available for the fabrication of composite materials.
CO2	Analysis the mechanical and tribological behaviour of the composite materials.
CO3	Develop various components made of MMCs, PMCs, CMCs. For different applications.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	2	3	-	-	-	-	-	-	3	3
CO2	3	2	3	2	3	-	-	-	-	-	-	3	3
CO3	3	2	3	2	3	-	-	-	-	-	-	3	3

1 – Low 2 – Medium 3 – High

Details Syllabus:

Introduction, definition and classification of composite materials: Types of reinforcements, Criteria for the selection of the matrices and reinforcements Its properties, Types of Matrixes, Interfaces, Wettability Its importance and application.

Polymers and Polymer Matrix Composites and Metals and Metal Matrix Composites: Its type, like Lamina, Laminates, Sandwich concept of Isotropy, Anisotropy and Orthotropy in composites.

Processing of Composites: Primary and Secondary Manufacturing Process of metal matrix composites like star casting, ultrasonic assisted star casting, centrifugal casting, concept of bottom pouring, top pouring their advantages and limitations, Powder metallurgy technique, Iso-static Compaction method. Fabrication method of polymer matrix composites like Hand Lay-Up technique, Compression Molding technique and Autoclave technique. Its mechanical and Tribological properties characterization.

Introduction of Ceramics and ceramic matrix composites: Types of Ceramic matrix composites, Ceramic-metal systems, Ceramic glass system, Ceramic-ceramic systems and Fabrication of ceramic matrix composites, Its mechanical and Tribological properties characterization.

Concept of Macro-Mechanism and Micro-Mechanics of composites: Prediction of Density and Elastic Modulus of composites. Problems based on density and elastic modulus of composites. Economics of Composites and Reinforcements, Design of Composite Materials.

Applications of Composites in different Sectors like Automobile, Aerospace and Food Packaging Industries etc. Concept of Nano-Materials and Nano-Composites. Micro-electromechanical Systems [MEMS], Nano-electromechanical Systems [NEMS].

Text Books:

1. Autar K. Kaw, Mechanics of Composite Materials, Taylor & Francis, 2006, 2nd Edition.
2. D. Hull and T.W. Clyne, An introduction to composite materials, Cambridge, 2012, 2nd Edition.

Reference Books:

1. Robert Millard Jones, *Mechanics of Composite Materials, Mechanics of Composite Materials,* CRC Press, 1999,1st Edition.
2. Jack R. Vinson, Robert L. Sierakowski, *the behaviour of structures composed of composite materials*, Springer, Dordrecht, 2006, 2nd Edition.

ME 3676 **3-0-0-3**

Introduction to FEM

Prerequisite: None

Course Outcomes:

CO1	Students will be able to understand the fundamental aspects of finite element method
CO2	Students will be able to formulate the 1D engineering problems and solve them by hand calculations and FE software.
CO3	Students will be able to formulate the 2D engineering problems and solve them by hand calculations and FE software.
CO4	Students will be able to understand the integration schemes and different element formulations in FEM.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	2	3	-	-	-	-	-	-	3	3
CO2	3	3	3	2	3	-	-	-	-	-	-	3	3
CO3	3	3	3	2	3	-	-	-	-	-	-	3	3
CO4	3	2	3	2	3	-	-	-	-	-	-	3	3

1 – Low 2 – Medium 3 – High

Details Syllabus:

Introduction: Basic concept, Historical background, and General applications of finite element method, Variational and Weighted Residual methods.

Approaches of FEM: Approaches of FEM: Discrete, Variational and Weighted Residual methods.

Direct Problems: 1-D Rod and Heat conduction, Truss Systems, Solution and its post processing by hand calculations and FE software/code.

Beam Bending Problems: Beam Bending: Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post process by hand calculations and FE software.

2-D Thermal and Plane stress, Plane strain and Axisymmetric Problems:
Finite element formulation for 2-D problems, constant strain triangle, various elements, iso-parametric, sub-parametric and super-parametric elements, interpolation functions, computer implementation and case studies.

Numerical Integration and 2-D problems of Elasticity: Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems.

Text Books:

1. Tirupathi R. Chandrupatla, Ashok D. Belegundu, *Introduction to Finite Elements in Engineering*, Pearson Education India, 4th Edition.
2. U.S. Dixit, *Finite Element Methods for Engineers*, Cengage Learning, New Delhi and Singapore, 1st Edition.

Reference Books:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, *Concept and Applications of Finite Element Analysis*, Wiley, 4th Edition.

ME 3677 **3-0-0-3**

Multi-Body Dynamics

Prerequisite: Engineering Mechanics (ME 1101).

Course Outcomes:

CO1	To understand the basic mathematical terminologies
CO2	To understand the various frameworks employed in the description of motion

CO3	To be able to formulate and solve the numerical aspect in modeling flexible systems
CO4	To understand and apply multi-body dynamics in various engineering applications

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	2	2	2	-	-	-	-	-	3	3
CO2	3	2	3	2	3	2	-	-	-	-	-	3	3
CO3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO4	3	3	3	2	3	2	-	-	-	-	-	3	3

1 – Low 2 – Medium 3 – High

Details Syllabus:

Overview of fundamentals of kinematics and kinetics, Geometric kinematics of rigid multibody systems: Coordinate systems, Rotation, Orientation, Motion and Multibody Kinematics.

Velocity and Acceleration kinematics of rigid multibody systems. Rigid body geometry and multi-body dynamics. Lagrangian and Newton-Euler formulations for rigid multi-body systems.

Flexible multi-body systems: classification, elastodynamics problem, Finite displacements kinematics for flexible bodies, strain measures for various differential elements. Equations of motion: formulation of flexible joints, cable equations, beam equations, plate and shell equations. Finite element tools for multibody problems.

Application case studies: manipulators, vehicles etc.

Text Books:

1. Ahmed A. Shabana, *Dynamics of Multibody Systems*, Cambridge University Press, 3th Edition, 2005.
2. O. A. Bauchau, *Flexible Multibody Dynamics*, Springer Dordrecht, 1st Edition, 2010.

Reference Books:

1. Reza N. Jazar, *Advanced Dynamics: Rigid Body, Multibody, and Aerospace Applications*, John Wiley and Sons, 1st Edition.

ME 3678 **3-0-0-3**

Introduction to Power Plant Engineering

Prerequisite: Engineering Thermodynamics (ME2302), Applied Thermodynamics (ME 2401)

Course Outcomes:

CO1	To gain an understanding of the fundamental theories of various types of powerplants
CO2	To describe and analyze the various systems and sub-systems used in steam, gas turbine, and combined cycle power plants.
CO3	To be able to evaluate the environmental and sustainability considerations in this field.
CO4	To be able to utilize advanced solidification techniques and their applications.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Details Syllabus:

Introduction: Overview and classification of power plants, Site selection criteria for different types of power plants, Load curve, load duration curve, base load and peak load plants.

Steam Power Plants: Rankine cycle and its modifications, Boiler Types and Operations (Fire-tube, water-tube, and supercritical boilers), Steam turbines and their governing methods, Fuel handling, combustion systems, ash and dust handling.

Nuclear and Hydroelectric Power Plants: Nuclear reactions, fission and fusion, types of reactors (PWR, BWR, PHWR, Fast Breeder), Reactor components: fuel, moderator, control rods, coolant, shielding, Safety measures and waste disposal, Hydroelectric plant layout, dams, Hydraulic turbines, Pumped storage plants.

Non-Conventional Power Generation: Solar thermal and photovoltaic power systems, Wind power generation: types, characteristics, and power curves, Geothermal, tidal, and biomass energy systems.

Text Books:

1. P K Nag, Power Plant Engineering, McGraw Hills, 4th Edition.

Reference Books:

1. Harish C Rai, Shipra Rai, *Power Plant Engineering*, Wiley, 2nd Edition.
2. Sudipta De, Nag's, *Power Plant Engineering*, McGraw Hills, 5th Edition.

ME 3679 **3-0-0-3**

Introduction to Power Plant Engineering

Prerequisite: NA

Course Outcomes:

CO1	To gain an understanding of the fundamental theories of various types of powerplants
CO2	To describe and analyze the various systems and subsystems used in steam, gas turbine, and combined cycle power plants.
CO3	To be able to evaluate the environmental and sustainability considerations in this field.
CO4	To be able to utilize advanced solidification techniques and their applications.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Details Syllabus:

Advanced Metal forming Process: Unconventional Forming Methods: Classification, Process Principle, Applications, Equipment's, Process Analysis and Die Design of Explosive Forming, stretch forming, Contour roll forming Laser Beam Bending and Laser Assisted Deep Drawing. Micro Forming Processes: Classification, Process Principle and Applications of Conventional Micro Forming Processes, Unconventional Micro-Forming Processes.

Advanced Metal casting Process: Metal mould casting basics, continuous casting, permanent mould casting, pressure die casting, Vacuum mould casting, Evaporative pattern casting (EPC)- Hybrid and vacuum, Ceramic shell investment casting.

Specialized Moulding Techniques: Injection moulding using pressurized gas assistance, Injection moulding using reaction gas assistance, Injection Moulding for Thin-Wall Applications, Multi-Material Injection Moulding, Water-Assisted Foaming, Moulding by direct compounding, Injection Compression Moulding. Ultrasonic Molding Technology: Recent Advances and Potential Applications in the Medical Industry, Variable Mold Temperature Technologies, Micro injection molding-Issues in Molding Parts with Microfeatures, Influencing Factors in Microinjection Molding, Applications.

Welding-Based Additive Manufacturing (WAM): Classification of WAM by motion controller, raw material and heat source. Powder-bed AM: Selective laser sintering (SLS), Selective Laser Melting (SLM) and Electron Beam Melting (EBM). Wire-feed based WAM: Wire and Laser Additive Manufacturing (WLAM), Electron Beam Freeform Fabrication (EBF3), Wire and Arc Additive Manufacturing (WAAM).

Ultra-Precision Machining: Diamond turning- mechanism of material removal - process Parameters and Optimization- tool path strategies in surface generation- applications.

Micro manufacturing: Focused ion beam (FIB) Micro-/Nano-fabrication, Laser Micro structuring. Hot Embossing, Hot punching, Roller Embossing, Applications-Micro optical devices, Micro fluidic devices. Net Shape Manufacture of Freestanding Ceramic Micro-components through Soft Lithography, micro-fields-activated sintering technology (Micro-FAST). Micromachining- Micro turning, Micro grinding, Ultra Sonic Micromachining, Abrasive Water Jet Micro Machining, Chemical and Electro Chemical Micro Machining – Electric discharge micro machining, Laser Beam Micro Machining. Handling for Micro-manufacturing.

Text Books:

1. Kalpakjian and Schmid, *Manufacturing Processes for Engineering Materials*, Prentice Hall, 2017, 5th edition.
2. Hassan Abdel-Gawad ElHofy, *Fundamentals of Machining Processes (Conventional and Nonconventional Processes),* CRC Press, 2018, 3rd Edition.
3. V.K. Jain, Micro manufacturing processes, CRC Press, 2013, 1st Edition.

Reference Books:

1. Murty, R. L. *Precision Engineering in Manufacturing*, New Age International (P) Limited, 1996, 1st Edition.
2. Mark J. Jackson, *Micro and Nano fabrication,* CRC Press, Taylor & Francis Group, 2010, 1st Edition.
3. MuammerKoc, TrugelOzel, *Micro manufacturing, Design, and manufacturing of micro products*, Wiley Publishers, 2011, 1st Edition.

Syllabus of Departmental Elective III Courses

ME 4771 **3-0-0-3**

Solar Energy Conversion Technology

Prerequisite: Fluid Mechanics (ME 2304), Heat and Mass Transfer (ME 3501).

Course Outcomes:

CO1	Describe the global and Indian energy scenario, classify energy sources, and apply fundamental thermodynamic laws to renewable energy systems.
CO2	Analyze the geometry of solar radiation, including Earth-Sun relationships, solar angles, and estimation of radiation on various surfaces using Indian data.
CO3	Explain the working principles and performance of various solar thermal systems such as flat plate collectors, solar water heaters, dryers, cookers, and thermal storage systems.
CO4	Evaluate the design and performance of concentrated solar power (CSP) systems and their role in thermal-to-mechanical energy conversion.
CO5	Design and assess photovoltaic systems, understand the principles of PV conversion, and analyze system economics for both off-grid and on-grid applications.
CO6	Understand the mechanisms of solar photocatalysis, and explore recent advances and emerging solar energy technologies for environmental and energy applications.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Overview of Global and Indian energy scenario, sources of energy and its classifications, renewable energy sources, classification and systems, overview of 1st, 2nd and 3rd law of thermodynamics, thermodynamic processes and basic cycles.

Solar Radiation: Extra-terrestrial and terrestrial radiation, radiation measurements, Earth-Sun relation, solar angles, day length, angle of incidence on tilted surface, sun path diagrams,

shadow determination, extraterrestrial characteristics, effect of earth atmosphere, measurement and estimation on horizontal and tilted surfaces, Indian solar radiation data.

Solar Thermal Conversion: Fundamentals, flat plate collectors-liquid and air type, theory of flat plate collectors, selective coatings, advanced collectors, solar water heaters, solar air

heaters, solar cooker, solar dryers, solar stills, solar pond, solar cooling and refrigeration, thermal energy storage, passive and active conditioning of buildings.

Concentrated Solar Power: Conversion of heat into mechanical energy, solar thermal power generation**.**

Solar Photovoltaics: Principle of photovoltaic conversion, fabrication of photovoltaic devices, PV system applications (water pumping etc.), PV power plant, PV system design and economics (off grid and on grid), new generation solar cells and emerging technologies.

Solar Photocatalysis: Mechanism, kinetics, performance parameters, applications, recent advances in solar energy technologies.

Text Books:

1. S. P. Sukhatmeand J. K. Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill, 3rd Edition.
2. Arvind Tiwari, G. N. Tiwari, and Shyam, *Handbook of Solar Energy Theory Analysis and Applications*, Springer, 1st Edition.

Reference Books:

1. C. S. Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Applications*, Prentice Hall India, 2nd Edition.

ME 4772 **3-0-0-3**

Cryogenics Engineering

Prerequisite: Refrigeration and Air Conditioning (ME 3604).

Course Outcomes:

CO1	The knowledge on the properties of both matter and fluid for better design of the process engineering in cryogenics application.
CO2	Understanding the gas separation system and able to calculate the no of plates require for the gas separation process at low temperatures.

CO3	Instrumentation in cryogenic system is essential for measuring properties at low temperature
CO4	Understand the importance of the storage and transfer systems of the cyrogens (LOx, LN2, LH2, LHe)
CO5	Safety in cryogenics is highly important for handling liquids or cryogens environment.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Details Syllabus:

Properties of Solid and Liquid at Low Temperature – Mechanical, thermal, electrical, and superconductivity properties of engineering materials. Properties of cryogens viz., Oxygen, Nitrogen, Hydrogen, Helium, and Neon.

Separation and Purification Systems – Ideal separation of gases, characteristics of mixtures, principles of gas separation, calculation of number plate column for gas separation, air separation systems, hydrogen separation systems, helium separation systems, gas purification.

Cryogenic Instrumentation – Properties characterizing cryogenic instrumentation, temperature, pressure, liquid level, displacement and position.

Storage and Transfer Systems – Insulation concepts, storage systems for cryogenic liquids, transfer systems, industrial storage and transfer, safety of the cryogenics system.

Text Books:

1. Randall F. Barron, *Cryogenics Systems*, Oxford Univesity Press New York, 2nd Edition.
2. C P Arora, *Refrigeration and Air Conditioning*, McGraw Hill Education, 3rd Edition.

Reference Books:

1. Klaus D. Timmerhaus, Thomas M. Flynn, *Cryogenic Process Engineering*, Springer New York, NY, 1st Edition.

ME 4773 **3-0-0-3**

Experimental Methods in Mechanical Engineering

Prerequisite: None.

Course Outcomes:

CO1	Explain the fundamentals of engineering experimentation and measurement systems.
CO2	Evaluate static performance characteristics of measurement systems.
CO3	Analyze experimental data using statistical and uncertainty methods.
CO4	Apply measurement techniques for force, pressure, flow, strain, and temperature.
CO5	Design and execute experiments using data acquisition systems.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	3	-	-	-	-	-	-	3	3	3
CO2	2	2	3	2	-	-	-	-	-	-	2	2	2
CO3	3	2	3	3	-	-	-	-	-	-	3	3	2
CO4	3	3	3	3	-	-	-	-	-	-	3	3	3
CO5	3	2	3	3	-	-	-	-	-	-	3	3	3

1 – Low 2 – Medium 3 – High

Details Syllabus:

Introduction to Engineering Experimentation- Theory and experimentation in engineering, problem-solving approaches, types of engineering experiments, design of experiments, computer simulation and physical experimentation, generalized measuring system, types of inputs, analog and digital signals, standards, calibration, and uncertainty.

Measurement System and Performance - Measurement system performance characteristics, static performance characteristics, static calibration, linearity, static sensitivity, repeatability, hysteresis, threshold, resolution, readability, and span.

Experimental Data Analysis - Causes and types of experimental errors, uncertainty analysis, statistical analysis of data, probability distributions, curve fitting, dynamic performance characteristics, input types, and instrument types—zero-order, first-order, and second-order instruments.

Measurement Methods and Applications - Model building and experiment planning, measurement of force and torque, measurement of strain and stress, pressure measurement, flow measurement and flow visualization, temperature measurement, and optical methods of measurement.

Data Acquisition and Project Execution- Data acquisition systems (DAS) types and configurations/LabVIEW, signal conditioning, A/D and D/A conversion, design, planning, execution, and analysis of experimental projects.

Text Book:

1. J.P. Holman, *Experimental Methods for Engineers*, McGraw-Hill, 9th Edition.

Reference Books:

1. Thomas Beckwith, Roy Marangoni, *Mechanical Measurements*, Pearson, 2nd Edition.

ME 4774 **3-0-0-3**

Design of Transmission Elements

Prerequisite: None

Course Outcomes:

CO1	To understand the types belt drives and Select suitable belt drives and associated elements from manufacturers catalogues under given loading conditions to design the springs for different loading conditions.
CO2	To understand the design of spur gears.
CO3	To understand the design of bevel and helical gears.
CO4	To understand the design of a gear box.
CO5	To analyze and design the power transmission mechanisms in cams, clutches and brakes.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	3	2	-	-	-	-	-	2	3	2
CO2	3	2	3	3	2	-	-	-	-	-	2	3	2
CO3	3	2	3	3	2	-	-	-	-	-	2	3	2
CO4	3	2	3	3	2	-	-	-	-	-	2	3	3
CO5	3	2	3	3	2	-	-	-	-	-	2	3	3

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Design of flexible elements: Design of Flat belts and pulleys — Selection of V belts and pulleys Selection of hoisting wire ropes and pulleys — Design of Transmission chains and Sprockets.

Spur gears and Parallel Axis Helical gears: Speed ratios and number of teeth-Force analysis -Tooth stresses — Dynamic effects — Fatigue strength — Factor of safety — Gear materials — Design of straight tooth spur & helical gears based on strength and wear considerations — Pressure angle in the normal and transverse plane- Equivalent number of teeth-forces for helical gears.

Bevel, worm and cross helical gears: Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears. Worm Gear: Merits and demerits- terminology. Thermal capacity, materials-forces and stresses, efficiency, estimating the size of the worm gear pair. Cross helical: Terminology-helix angles-Estimating the size of the pair of cross helical gears.

Gear boxes: Geometric progression — Standard step ratio — Ray diagram, kinematics layout -Design of sliding mesh gear box — Design of multi speed gear box for machine tool applications — Constant mesh gear box — Speed reducer unit. — Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications.

Cams, clutches and brakes: Cam Design: Types-pressure angle and under cutting base circle determination-forces and surface stresses. Design of plate clutches –axial clutches-cone clutches-internal expanding rim clutches- Electromagnetic clutches. Band and Block brakes — external shoe brakes — Internal expanding shoe brake.

Text Books:

1. V B Bhandari, *Design of Machine Elements*, McGraw Hill, 5th Edition.
2. Richard G. Budynas, J. Keith Nisbett, Kiatfa Tangchaichit, Shigley's, *Mechanical Engineering Design*, McGraw Hill, 11th Edition.

Reference Books:

1. Robert L Norton, *Machine Design: An Integrated Approach*, Pearson Education India, 5th Edition'.

ME 4775 **3-0-0-3**

Advanced Finite Element Methods

Prerequisite: Introduction to FEM (ME 3676)

Course Outcomes:

CO1	To be able to understand and implement time stepping procedures in FEM
CO2	To understand non-linearity and the iterative procedures

CO3	To understand material nonlinearity and implement the basic 1D nonlinear FEM code
CO4	To understand displacement- and force-controlled setup, introduce to arc-length methods, the various methodologies involved in solving buckling problems

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Time dependent problems with explicit and implicit time integration schemes for solid and heat transfer problems.

Introduction to non-linearity in 1D problems, Weak formulation, Linearization, Newton-Raphson procedures.

Introduction to 1D inelasticity, FEM procedures for 1D inelastic problems.

FEM for buckling, post-buckling procedures in frame structures.

Text Books:

1. Klaus - Jurgen Bathe, *Finite Element Procedures*, PHI Learning Pvt. Ltd., 1996.

Reference Books:

1. René de Borst, Mike Crisfield, Joris Remmers, Clemens Verhoosel, *Nonlinear Finite Element Analysis of Solids and Structures*, John Wiley & Sons Ltd, 2nd Edition, 2012.

ME 4776 **3-0-0-3**

Introduction to Mechanical Micro-Machining

Prerequisite: None

Course Outcomes:

CO1	Comprehend and analyze atomic-scale phenomena, scaling laws, and their influence on mechanical micro machining processes.

CO2	Identify and analyze key micro machining mechanisms such as burr formation, surface finish, built-up edge, and effects of tool geometry and cutting fluids.
CO3	Apply and analyze the fabrication of micro cutting tools, structure of micro machine tools, and their functional integration in machining processes.
CO4	Evaluate and synthesize precision machining techniques like diamond turning and advanced metrology used in micro-scale manufacturing.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed syllabus:

Experimental observations and theoretical prediction of constituents of an atom. Scaling law. Mechanical micro machining (process, mechanism). Burr formation, surface roughness, built up edge.
Cutting fluid, run out, grain size. Micro machine structure. Fabrication of micro cutting tools. Miniature machine tools. Diamond Turning (process, types, mechanism, applications). Metrology for micro machining.

Text Books:

1. Cheng, Huo, *Micro-Cutting: Fundamentals and Applications*, Wiley Publication, 2013, 1st Edition.
2. V. K. Jain, *Introduction to Micromachining*, Narosa Publishing House, 2014, 2nd Edition.

Reference Books:

1. David Dornfeld and Dae-Eun Lee, *Precision Manufacturing*, Springer US, 2008, 1st Edition.

ME 4777 **3-0-0-3**

Introduction to Computational Fluid Dynamics

Prerequisite: Fluid Mechanics (ME2304)

Course Outcomes:

CO1	Explain various methods of CFD and compare with experimental and theoretical analysis

CO2	Formulate the governing equations and solve the numerical problem.
CO3	Derive finite volume method and apply to 2-D and 3-D problems

Course Articulation Matrix:

COs	POs											PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	2	2	-	-	-	-	-	-	3	2
CO3	3	3	3	2	2	-	-	-	-	-	-	3	2

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Linear system of algebraic equations. Numerical solution of parabolic equations - **Stability analysis.**

Numerical solution of hyperbolic equations - **Burger's equation.**

Incompressible Navier Stokes equations and algorithms – **Basics of grid generation.**

Text Books:

1. J.D Andeson, Computational Fluid Dynamics – The basics with applications,Mc Grew Hill, 1995, 1st Edition.

References Books:

1. H.K. Versteeg, and W.Malalasekera, Longma, *An Introduction to Computational Fluid Dynamics – The finite volume method*, Scientific & Technical, 1995, 1st Edition,
2. S.V. Patankar, Hemisphere, *Numerical Heat Transfer & Fluid Flow*, CRC Press, 1980,

ME 4778 **3-0-0-3**

Additive Manufacturing

Prerequisite: None

Course Outcomes:

CO1	Understand the working principle and process parameters of AM processes
CO2	Explore the applications of AM processes in various fields
CO3	Apply the suitable process and material for fabricating a given product

CO4	Use the suitable post process based on product application
CO5	Design and develop a product for AM Process

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to Additive Manufacturing (AM): Overview, History, Need, Classification, Additive Manufacturing Technology in product development, CAD & Reverse Engineering, CAD model preparation – Part Orientation and support generation, Model Slicing, Tool path Generation, Software for Additive Manufacturing Technology.

Materials for AM: Atomic Structure and Bonding, Nature of Polymers, Thermoplastics and

Thermosetting Polymers, Types of Polymerizations, Properties of Polymers, Degradation of Polymers, Metal and Ceramic Powders, Composites, Functionally Graded Materials (FGM's).

Text Books:

1. Ian Gibson, David W. Rosen, and Brent Stucker, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*, Springer, 2015, 2nd Edition.
2. Patri K. Venuvinod and Weiyin Ma, *Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, World Scientific, 2015, 4th Edition.

References Books:

1. Patri K. Venuvinod and Weiyin Ma, *Rapid Prototyping: Laser-based and Other Technologies*, Springer, 2004, 2nd Edition.
2. D.T. Pham, S.S. Dimov, *Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, Springer, 2001, 3rd Edition.

Syllabus of Departmental Elective IV Courses

ME 4871 **3-0-0-3**

Failure Analysis and Design

Prerequisite: None

Course Outcomes:

CO1	Recognize and describe common engineering failure mechanisms
CO2	Predict the remaining useful life of the components using fatigue, fracture and creep
CO3	Understand the various aspects of wear and corrosion
CO4	Analyze the failed engineering components

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction, causes of failures, classification, steps in failure analysis, tools, sample selection and treatment, materials analysis, equipments, Metallography, commonly used NDT methods. Machine condition monitoring techniques and condition monitoring of gearboxes.

Failure mechanisms, overload failure, ductile and brittle fracture, ductile to brittle transition, stress concentration approach. Fracture mechanics approach, Fatigue mechanisms, classical fatigue prevention and prediction, fractography, damage tolerant fatigue approach.

Wear failures, adhesive, abrasive, erosive, corrosive wear. Elevated temperature failures, creep, creep crack branching. Corrosion failures, types and their identification.

Application and case studies on Failure analysis: Failures of cast and welded components, failures of rotating components-shaft, bearing and gears.

TextBooks:

1. David R.H. Jones, *Materials Failure Analysis: Case Studies and Design Implications*, Pergamon Press, 1st Edition, 1993.
2. Ralph I. Stephens, Ali Fatemi, Robert R. Stephens, Henry O. Fuchs, *Metal fatigue in Engineering*, Wiley India Pvt Ltd, 2nd Edition, 2002.

Reference Books:

1. Brett A. Miller, Roch J. Shipley, Ronald J. Parrington, and Daniel P. Dennies, *ASM Handbook, Vol.11, "Failure Analysis and Prevention",* ASM Publications, 10th Edition, 2002.

ME 4872 **3-0-0-3**

Convective Heat Transfer

Prerequisite: Heat and Mass Transfer (ME 3501)

Course Outcomes:

CO1	To gain an understanding of the fundamental theories of convective heat transfer.
CO2	To analyze heat transfer in external forced convection scenarios.
CO3	To develop the skills to evaluate heat transfer in internal forced convection scenarios.
CO4	To apply the concepts of natural and mixed convection to practical engineering problems.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Classification, Governing equations, Dimensional analysis and similarity parameters, Boundary layers: thermal and velocity, Blasius solution

Forced Convection: Convective heat transfer over flat plates and cylinders, Flow over spheres and non-circular bodies, Internal flow: fully developed laminar and turbulent flows in pipes, Thermal entrance region and Graetz number.

Natural Convection and Mixed Convection: Governing equations and similarity solutions, Vertical and horizontal plates, cylinders, and enclosures, Natural convection correlations for engineering applications, Introduction to mixed convection.

Applications: Heat transfer with phase change: condensation and boiling, Convection in HVAC, electronics cooling, and energy systems, Finite Difference Methods, Finite Volume Methods, convection in porous media and nanofluids.

Text Books:

1. Adrain Bejan, *Convection Heat Transfer*, Wiley & Sons, 4th Edition**.**

Reference Books:

1. Frank P. Incropera, David P. Dewitt, Theodore L. Bergman, Adrienne S. Lavine, Incropera's *Principles of Heat and Mass Transfer*, Wiley & Sons, 1st Edition.

ME 4873 **3-0-0-3**

Introduction to Solidification Processing

Prerequisite: Heat and Mass Transfer (ME 3501), Materials Engineering (ME 2301).

Course Outcomes:

CO1	To gain an understanding of the fundamental principles and theories underlying the solidification process.
CO2	To be able to analyze the solidification behavior of pure metals and alloys, including microstructure development
CO3	To be able to develop the skills to identify common solidification defects and implement strategies to control and prevent them
CO4	To be able to identify and evaluate the diverse applications of microfluidics.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Fundamentals of Solidification: Overview, Thermodynamics of phase transformation, Homogeneous and heterogeneous nucleation, Growth of crystals: planar, cellular, dendritic.

Heat Transfer and Interface Stability: Heat flow in solidification: conduction and convection, Thermal gradients and cooling curves, Interface stability and constitutional supercooling, Solute redistribution and Scheil's equation.

Solidification Defects: Types of solidification defects: shrinkage, porosity, hot tearing, segregation, Causes and Prevention of Defects, Computational methods for predicting solidification behaviour, Inspection techniques for solidified products.

Advanced Topics in Solidification: Rapid Solidification, Directional Solidification, Solidification in Additive Manufacturing, Future Trends and Innovations.

Textbooks:

1. Martin Eden Glicksman, *Principles of Solidification: An Introduction to Modern Casting and Crystal Growth Concepts*, Springer, 1st Edition.

References:

1. David A Porter, Kenneth E Easterling, Mohamed Y Sherif, *Phase Transformations in Metals and Alloys*, CRC Press, 3rd Edition.

ME 4874 **3-0-0-3**

Renewable Energy Engineering

Prerequisite: Heat and Mass Transfer (ME 3501), Applied Thermodynamics (ME 2401)

Course Outcomes:

CO1	Understand and evaluate the potential and utilization of solar energy systems for different applications.
CO2	Analyze and compare biomass conversion techniques and assess bioenergy systems.
CO3	Interpret wind data and design basic wind energy systems for practical applications.
CO4	Identify and describe working principles of geothermal, tidal, and other advanced renewable technologies.
CO5	Apply the principles of renewable energy systems in real-world problem-solving and sustainable energy planning.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	-	-	-	-	-	-	3	1
CO2	3	3	2	2	3	-	-	-	-	-	-	3	2

CO3	3	3	3	2	2	-	-	-	-	-	-	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	3	3
CO5	3	2	3	2	2	-	-	-	-	-	-	3	2

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Solar Energy Systems - Basics of solar energy, solar radiation – extraterrestrial and terrestrial, measurement and estimation, solar angles and geometry, relevant heat transfer equations, solar thermal energy conversion – flat plate and concentrating collectors.

Bioenergy Technologies - Biomass sources and classifications, fuel properties, biomass conversion – thermochemical and biochemical routes, anaerobic digestion and biogas production, types and design of biogas plants, biomass gasifiers – working principle and types, introduction to biofuels – biodiesel and bioethanol production and uses.

Wind Energy Systems - Wind energy fundamentals, wind data analysis, site selection, energy estimation methods, wind turbine types – horizontal and vertical axis, basic aerodynamics, components and performance of windmills, grid-connected and standalone systems, applications in rural and small-scale energy supply.

Emerging and Alternative Renewable Sources - Overview of geothermal and tidal energy – principles, systems, and applications, basics of wave energy systems, magneto-hydrodynamic (MHD) generation – concept and applications, thermionic converters – working principles, introduction to fuel cells – types, working mechanism, and applications in clean energy.

Text Books:

1. S. P. Sukhatmeand J. K. Nayak, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw Hill, 3rd edition.
2. Rao, S. and Parulekar, *Energy Technology - Nonconventional, Renewable and Conventional*, R. BKhanna Publishers, 1st Edition.

Reference Books:

1. Le Gourieres, D, *Wind Power Plant - Theory and Design*, Pergaman Press, 1st Edition.

ME 4875 **3-0-0-3**

Non-Traditional Machining

Prerequisite: None

Course Outcomes:

CO1	Comprehend and analyze various unconventional machining processes including their classification, mechanism, and applications.

CO2	Identify and analyze the working principles, tool design, and process parameters of processes like EDM, ECM, LBM, and USM.
CO3	Apply and analyze advanced surface finishing techniques for achieving high-precision components.
CO4	Evaluate and synthesize analytical/numerical models and computer-aided process planning strategies for optimizing non-traditional machining processes.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

General classification of unconventional machining processes; Abrasive jet machining, water jet

And abrasive water jet machining, ultrasonic machining; Electric discharge machining and allied processes, laser beam machining, ion beam machining, plasma arc machining;

Electro chemical machining (ECM) and allied processes: ECM tool design, chemical machining, photochemical machining; Elastic emission machining;

Advanced finishing processes, abrasive flow finishing, magnetic abrasive finishing, magneto rheological finishing, chemo-mechanical polishing; Comparative evaluation of different unconventional machining processes; Analytical modelling of mechanical, thermal and electrochemical type non-traditional machining processes;

Numerical modelling and simulation of unconventional machining processes; Computer aided process planning of non-traditional machining processes.

Text Books:

1. Gary F. Benedict, *Nontraditional Manufacturing Processes*, Taylor & Francis, 1987.
2. P. C. Pandey and H. S. Shan, *Modern Machining Processes*, Tata McGraw-Hill Education, 1980.

References Books:

1. V. K. Jain, *Advanced Machining Processes*, Allied Publishers, 2009.

ME 4876 **3-0-0-3**

Green Manufacturing

Prerequisite: None

Course Outcomes:

CO1	Comprehend and analyze the environmental effects of design, inefficient energy usage, and need for recycling-oriented product development.
CO2	Identify and analyze material flow cycles, recycling practices, and mass balance analysis in achieving emission-less manufacturing.
CO3	Apply and analyze green manufacturing strategies including design for disassembly, risk assessment, and eco-design principles.
CO4	Evaluate and synthesize the use of renewable energy systems and environmentally friendly materials using full-cost accounting approaches.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	-	-	-	-	-	-	-	-	3	2
CO2	3	2	3	-	-	-	-	-	-	-	-	3	2
CO3	3	2	3	-	-	-	-	-	-	-	-	3	2
CO4	3	2	3	-	-	-	-	-	-	-	-	3	2

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Environmental effects of design – Environmental damage – In efficient energy use – Design for recycling.

Material flow and cycles – Material recycling – Emission less manufacturing.

Mass balance analysis – Green indicates – Design for disassembly design for recycle – Rist analysis – Material selection. Eco design – Industrial Ecology – Pollution prevention – Reduction of toxic emission.

Solar energy devices – wind energy resources – Full cost accounting methodology – Selection of natural friendly materials.

Text Books:

1. Cairncrss and Francis, *Costing the earth*, Harvard Business School Press, 1992, 2nd Edition.
2. Gradel.T.E. and B.R. Allenby, *Industrial Ecology*, Prentice Hall, 2003, 2nd Edition.

References:

1. World commission on Environment and Development (WCED), *Our Common Future*, Oxford University Press, 1987, 1st Edition.

ME 4877 **3-0-0-3**

Reliability Analysis and Materials Management

Prerequisite: None

Course Outcomes:

CO1	Understand and comprehend the fundamentals of reliability analysis of engineering components and systems.
CO2	Explain and describe the modus operandi for replacement or repair, maintenance, inspection and quality control.
CO3	Identify and investigate the system depicting the probable causes of failure and needs for maintenance.
CO4	Design and analyse the component or system based on reliability analysis.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Details Syllabus:

Basic concept of reliability: Importance of reliability in design, Introduction to mathematical statistic and statistical distribution theorem. Basic reliability principles, Single probability, Load-strength interaction, Bath Tub curve, non-constant failure rate, Introduction to simple Weibull plot.

Introduction to reliability function: Structure functions, reliability of systems of independent components, bounds on the reliability function, the inclusion exclusion method, the intersection method. Replacement, maintenance and inspection: examples and policies, life time and failure rates, expected system life time, fixed time replacement, preventive replacement, group replacement, control limit rules.

Introduction to quality control: Examples and definitions, acceptance sampling, operating characteristic curve, sampling inspection plan, control charts, average run length, control chart construction, inspection problems, identification of risk factors, estimating survival functions.

Reliability in design: defining the user requirement, setting reliability metrics and definitions, risk assessment, objective based framework for product development. Aspects of reliability: Reliability in development, physics of failure, fault tree analysis, design reviews, critical items, production reliability, reliability qualification testing, failure mode effect analysis. Reliability assurance and maintainability, design from maintainability, logistic support analysis, life cycle costing, risk cost estimate, case studies.

Text Books:

1. Balaguruswamy E, *Reliability Engineering*, McGraw Hill Education (2017), 4th Edition.
2. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, McGraw Hill, 1997, 1st Edition.

References Books:

1. Patrick D. T. O'Connor, *Practical Reliability Engineering*, Wiley, 2008, 4th Edition.
2. Guang Yang, 2007, *Life Cycle Reliability Engineering*, Wiley, 1st Edition.

ME 4878 **3-0-0-3**

Product innovation and start – up Strategies

Prerequisite: None

Course Outcomes:

CO1	Understand and explain key concepts of innovation, entrepreneurship, and the startup ecosystem.
CO2	Apply design thinking and ideation techniques to develop innovative product ideas and solutions.
CO3	Construct viable business models using tools like the Business Model Canvas.
CO4	Analyze market needs, customer segments, and value propositions for proposed startups.

CO5	Evaluate funding sources, legal aspects, and operational strategies required for launching a startup
CO6	Develop and present a comprehensive startup plan including product strategy, business model, and go-to-market approach.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Details Syllabus:

Introduction to Innovation and Entrepreneurship: Concept and types of innovation (incremental, disruptive, etc.) - Role of innovation in economic development - Entrepreneurial mindset and characteristics - Startup ecosystem and stakeholders - National and global startup trends.

Idea Generation and Product Development: Creativity techniques: Brainstorming, SCAMPER, Mind Mapping - Design Thinking process: Empathize, Define, Ideate, Prototype, Test - Product development lifecycle - Minimum Viable Product (MVP) and rapid prototyping - User-centric design and feedback loops.

Business Models and Startup Strategies: Business Model Canvas and Value Proposition Design - Lean Startup methodology - Competitive analysis and go-to-market strategy - Startup marketing and branding - Legal structure of startups and regulatory compliance.

Funding, Scaling, and Sustainability: Funding stages: Bootstrapping, Angel, Venture Capital - Pitch deck preparation and investor relations - Scaling strategies and growth hacking - Intellectual Property Rights (IPR) and patent filing - Social entrepreneurship and sustainable innovation

Text Books:

1. Eric Ries, *The Lean Startup*, Crown Business, 2011, 1st Edition.
2. Alexander Osterwalder and Yves Pigneur, *Business Model Generation*, John Wiley & Sons, 2010, 1st Edition.
3. Idris Mootee, *Design Thinking for Strategic Innovation*, John Wiley & Sons, 2013, 1st Edition.

References Books:

1. Eric Ries, *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, Crown Business, 2011, 1st Edition.
2. Idris Mootee, *Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School*, Wiley, 2013, 1st Edition.
3. Alexander Osterwalder & Yves Pigneur, *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*, Wiley, 2010, 1st Edition.

ME 4879 **3-0-0-3**

Project Management

Prerequisite: None

Course Outcomes:

CO1	Understand and evaluate the potential and utilization of solar energy systems for different applications.
CO2	Analyze and compare biomass conversion techniques and assess bioenergy systems.
CO3	Interpret wind data and design basic wind energy systems for practical applications.
CO4	Identify and describe working principles of geothermal, tidal, and other advanced renewable technologies.
CO5	Apply the principles of renewable energy systems in real-world problem-solving and sustainable energy planning.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Details Syllabus:

Introduction- Introduction to Project Management, History of Project Management, Project Life Cycle. Project Analysis - Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.

Financial Analysis - Financial Estimates and Projections, Investment Criteria, Financing of Projects. Network Methods in PM - Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, other network models.

Optimization in PM: Time and Cost trade-off in CPM, crashing procedure, Scheduling when resources are limited.

Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

Text Books:

1. Prasanna Chandra, Project: *A Planning Analysis*, Tata McGraw Hill Book Company, 4th Edition.
2. Cleland, Gray and Laudon, *Project Management*, Tata McGraw Hill Book Company, 3rd Edition.
3. Jack R. Meredith and Samuel J., Jr. Mantel, *Project Management - A Managerial Approach*, John Wiley, 2011, 6th Edition.

References Books:

1. Eliyahu M Goldratt, *The Critical Chain*, Business novel, 1997, 4th Edition.
2. Project Management Institute (PMI*), A guide to the Project Management Body of Knowledge*, Project Management Institute, Inc. 2008, 4th Edition.

Syllabus of Open Elective I Courses

ME 4750 **3-0-0-3**

Sustainable Engineering

Prerequisite: NA

Course Outcomes:

CO1	Explain the key principles of sustainability and analyze how engineering practices influence sustainable development.
CO2	Assess environmental pollution issues and identify strategies for pollution control and carbon mitigation.
CO3	Evaluate various carbon capture techniques, including DAC and amine-based methods, for industrial applications.
CO4	Describe and compare different renewable energy sources and their integration into sustainable systems.
CO5	Apply sustainability tools such as LCA, EIA, and ISO standards in the design and evaluation of engineering projects.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Fundamentals of Sustainability and Development - Concept and need for sustainability, evolution and scope of sustainable development, dimensions of sustainability – environmental, economic, and social, nexus between technology and sustainability, Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM), carbon footprint and carbon credits.

Environmental Pollution and Management - Types and sources of pollution – air, water, and solid waste, zero waste and 3Rs, greenhouse gas emissions, global warming, climate change, ozone depletion, environmental laws and acts, carbon trading, introduction to carbon mitigation strategies.

Carbon Capture and Sustainability Tools - Carbon capture technologies – fundamentals and need, amine-based CO_2 capture systems, Direct Air Capture (DAC) principles and systems, integration with power and industrial sectors. ISO 14001:2015 environmental management

framework, Life Cycle Analysis (LCA), circular economy, biomimicry, Environmental Impact Assessment (EIA), industrial symbiosis.

Renewable and Sustainable Energy Systems - Conventional vs. non-conventional energy,

solar, wind, biomass, small hydro, geothermal, and ocean energy systems, fundamentals of fuel cells and hydrogen economy, mechanical system integration for energy efficiency, energy storage and smart grid concepts.

Sustainable Engineering Practices and Urban Systems- Green building concepts and sustainable habitats, green construction materials, energy efficiency in thermal and fluid systems, HVAC and building envelopes, sustainable transport, urban sustainability, smart cities, green engineering approaches and industrial best practices

Text Books:

1. Allen, D. T. and Shonnard, D. R., *Sustainability Engineering: Concepts, Design and Case Studies,* , Pearson Education, 1st Edition, 2011
2. Bradley A. Striebig, Adebayo A. Ogundipe, Maria Papadakis, *Engineering Applications in Sustainable Design and Development*, Cengage Learning, 1st Edition, 2016.

Reference Books:

1. Jennifer Wilcox, Strength of Materials, *Carbon Capture*, Springer, 1st Edition, 2012.

ME 4751 **3-0-0-3**

Optimization in Engineering

Prerequisite: NA

Course Outcomes:

CO1	To get an understanding and formulate optimization problems in engineering
CO2	To understand and solve single variable optimization problems
CO3	To understand and solve multi-variable optimization problems
CO4	To understand and solve optimization problems with constraints
CO5	To understand evolutionary based optimizations procedures

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction : Introduction to Engineering Design, Identification of Customer Requirements, Mapping Customer Requirements to Engineering Characteristics, Problem formulation, Optimization problems in Mechanical Engineering, Classification of methods for optimization.

Single-variable Optimization: Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.

Multiple-variable Optimization Optimal criteria, direct search methods (Box's, Simplex, Hooke-Jeeves, Conjugate methods), Gradient-based methods (Steepest Descent, Newton's, Marquardt's, DFP method). Formulation and Case studies

Constrained Optimization: KKT conditions, Penalty method, and Sensitivity analysis, direct search methods for constrained optimization, quadratic programming, Formulation, and Case studies.

Evolutionary Optimization algorithm: Genetic algorithms, simulated annealing, Anti-colony optimization, Particle swarm optimization

Text Books:

1. Singiresu S. Rao, *Engineering Optimization: Theory and Practice*, New Age International Private Limited, 4th Edition.
2. Kalyanmoy Deb, *Optimization for Engineering Design: Algorithms and Examples*, Prentice Hall India Learning Private Limited, 1st Edition, 1995.

Reference Books:

1. Edwin K. P. Chong and Stanislaw H. Zak, *An Introduction To Optimization*, Wiley, 4th Edition

ME 4752 **3-0-0-3**

Elements of Product Design Course Outcomes

Prerequisite: NA

Course Outcomes:

CO1	To be able to understand the basic aspects involved in product design
CO2	To be able to understand value engineering and Design For X (DFX),
CO3	To get familiarize with the importance and procedures to intellectual property rights and patenting
CO4	To be able to understand the importance and steps involved in reverse engineering and prototyping
CO5	To be able to formulate and layout the economics in product development

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	3	3	-	-	-	-	-	-	3	3
CO2	3	2	3	2	2	-	-	-	-	-	-	2	2
CO3	3	2	3	3	3	-	-	-	-	-	-	3	2
CO4	3	2	3	3	3	-	-	-	-	-	-	3	3
CO5	3	2	3	3	3	-	-	-	-	-	-	3	3

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Introduction to product design and manufacturing, Product design morphology, Visual Design, and Quality Function Deployment (QFD).

Value Engineering and DFX: Value Engineering, Material, and Manufacturing process selection, Design for Manufacturing, Assembly, and Maintenance, Design for Environment, and Quality Control.

Patents and Intellectual Property: Understanding Intellectual Property and Patenting, Procedures to Patenting

Reverse Engineering, Prototyping: Reverse methodologies and engineering steps, Understanding prototyping, Principles and planning of Prototyping.

Product development economics: Elements of Economic Analysis, Development of a Financial model, Sensitivity analysis, Trade-Offs, Influence of quality factors.

Text Books:

1. Karl Ulrich, Steven Eppinger, Maria C. Yang, *Product design and development*, McGraw-Hill Education, 6th Edition.
2. Kevin Otto and Kristin Wood, *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, 1st Edition, 2001.

Reference Books:

1. Edward B. Magrab, Satyandra K. Gupta, F. Patrick McCluskey, Peter Sandborn, *Integrated product and process design and development*, CRC Press, 2th Edition, 2009.
2. Vinesh Raja and Kiran J. Fernandes, *Reverse Engineering: An Industrial Perspective*, Springer London, 1st Edition, 2008.

ME 4753 **3-0-0-3**

Introduction to Medical Devices and its Design

Prerequisite: NA

Course Outcomes:

CO1	An understanding on process and stages of medical device design, its clinical trials and regulation requirements in testing.
CO2	To learn the Biopotentials considered in EMG, EOG, ECG, EEG.
CO3	To understand the medical diagnostics through in-vitro diagnostics and imaging.
CO4	To get knowledge on minimally invasive devices, advanced surgical tools and implants etc.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Medical Device Classification, Bioethics and Privacy, Biocompatibility and Sterilization Techniques, Design of Clinical Trials, Design Control & Regulatory Requirements.

Introduction to specific medical technologies: Biopotentials measurement (EMG, EOG, ECG, EEG).

Medical Diagnostics (In-vitro diagnostics), Medical Diagnostics (Imaging)

Minimally Invasive Devices, Surgical Tools and Implants, Medical Records and Telemedicine

Text Books:

1. John G. Webster, *Medical Instrumentation: Application and Design*, Wiley, 4th Edition.
2. Paul G. Yock, Stefanos Zenios, Josh Makower, Todd J. Brinton, Uday N. Kumar, F. T. Jay Watkins, *Biodesign: The Process of Innovating Medical Technologies*, Cambridge University Press, 2nd Edition.

Reference Books:

1. Marie B. Teixeira, *Design Controls for the Medical Device Industry*, CRC Press, 3rd Edition.
2. Paul H. King, Richard C. Fries, and Arthur T. Johnson, *Design of Biomedical Devices and Systems*, CRC Press, 4th Edition.

ME 4754 **3-0-0-3**

Automation and Control

Prerequisite: NA

Course Outcomes:

CO1	An understanding on automation and its importance, types of automation, components of automation, strategies and levels of automation.
CO2	Learn the constructions and working principle of different types of sensors and transducers.
CO3	Understand the constructions and working principle of different types of Actuators and drive systems.
CO4	To impart knowledge on the control elements.
CO5	To understand the different control schemes generally used to get best output.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to Automation
Introduction to automation: Types and strategies of automation, pneumatic and hydraulic components circuits, Mechanical Feeding and machine tool control to transfer the automation.

Sensors and Transducers: Sensors and transducers, performance terminology, displacement, position and proximity, velocity and motion, force, fluid pressure, liquid flow, liquid level, temperature, light sensors, selection of sensors.

Actuators and drive systems: Mechanical, Electrical, Hydraulic drive systems, Characteristics of mechanical, Electrical, Hydraulic and pneumatic actuators and their limitations.

Control system components: Introduction, classification of control system- classification of control systems on the basis of control signal used, Adaptive control system, Process control systems.

Process control: Introduction, concept of process control, Automatic controllers- digital controller, Electronic controllers, Pneumatic controllers, P-I controller, PD controller, P-I-D controller, Hydraulic-controllers.

Text Books:

1. Mikell P. Groover, *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson Education, 4th Edition.
2. Curtis D. Johnson, *Process Control Instrumentation Technology*, Pearson Education Limited, 8th Edition.

Reference Books:

1. Richard Shell, *Handbook Of Industrial Automation*, CRC Press, 1st Edition.
2. Stamatios Manesis, George Nikolakopoulos, *Introduction to Industrial Automation*, CRC Press, 1st Edition.

ME 4755 **3-0-0-3**

Intellectual Property Rights

Prerequisite: NA

Course Outcomes:

CO1	Identify different types of Intellectual Properties (IPs), the right of ownership, scope of protection as well as the ways to create and to extract value from IP.
CO2	Recognize the crucial role of IP in organizations of different industrial sectors for the purposes of product and technology development.
CO3	Identify activities and constitute IP infringements and the remedies available to the IP owner and describe the precautious steps to be taken to prevent infringement of proprietary rights in products and technology development.
CO4	Be familiar with the processes of Intellectual Property Management (IPM) and various approaches for IPM and conducting IP and IPM auditing and explain how IP can be managed as a strategic resource and suggest IPM strategy.
CO5	Be able to anticipate and subject to critical analysis arguments relating to the development and reform of intellectual property right institutions and their likely impact on creativity and innovation.
CO6	Be able to demonstrate a capacity to identify, apply and assess ownership rights and marketing protection under intellectual property law as applicable to information, ideas, new products and product marketing.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	3	3	2	3	-	-	-	-	-	-	2	2
CO2	2	2	3	2	3	-	-	-	-	-	-	2	2
CO3	2	2	3	2	3	-	-	-	-	-	-	2	2
CO4	2	2	3	2	3	-	-	-	-	-	-	2	2
CO5	2	2	3	2	3	-	-	-	-	-	-	2	2
CO6	2	3	3	2	3	-	-	-	-	-	-	2	2

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents; their definition; granting; infringement ;searching & filing; Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs & Patents, Introduction to Intellectual Property Law

Introduction to Trademark — Trademark Registration Process — Post registration Procedures —Trade mark maintenance - Transfer of Rights - Infringement — Dilution Ownership of Trademark — Likelihood of confusion - Trademarks claims — Trademarks Litigations

International Trademark Law. Design- Meaning, Definition, Object, Registration of Design, Cancellation of Registration, International convention on design, functions of Design, etc.

Introduction to Copyrights — Principles of Copyright Principles -The subjects Matter of Copyright — The Rights Afforded by Copyright Law — Copyright Ownership, Transfer, and duration — Right to prepare Derivative works — Rights of Distribution — Rights of Perform the work Publicity Copyright Formalities and Registrations — Copyright disputes and International Copyright Law.

Introduction to Trade Secret — Maintaining Trade Secret — Physical Security — Employee Limitation - Employee Confidentiality Agreement - Trade Secret Law - Unfair Competition Trade Secret Litigation — Breach of Contract. Geographic indication, World Intellectual Property Organization, Paris Convention, Managing intellectual property in a knowledge-based society. IPR and technology transfer, Amendments in the IPR case studies

Text Books:

1. Deborah E. Bouchoux, *Intellectual Property*, Cengage learning Inc Pub, 4th Edition, 2012.
2. Deborah E. Bouchoux, *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*, Cengage Learning, 3rd Edition, 2012

Reference Books:

1. Prabuddha Ganguli, I*ntellectual Property Rights: Unleashing the Knowledge Economy*, McGraw Hill Education, 1st Edition, 2011.
2. Kompal Bansal, *Fundamentals of Intellectual Property for Engineers*, BS Publications, 1st Edition, 2013

ME 4756 **3-0-0-3**

Operations Research

Prerequisite: NA

Course Outcomes:

CO1	To gain an understanding of the fundamental principles and theories underlying Operations Research.
CO2	To formulate and solve various optimization problems using linear, integer, dynamic programming techniques.
CO3	To apply queuing theory, inventory management and simulation techniques in practical scenarios.
CO4	To gain proficiency in planning and managing engineering projects using network models.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Linear Programming: Overview of Operations Research, Formulation of Linear Programming Problem, Graphical method and Simplex method for solving LPP, Introduction to duality and sensitivity analysis.

Optimization Techniques: Integer Programming (Gomory cutting plane method), Transportation problems (North-West Corner, Least Cost, Vogel's Approximation, MODI method), Assignment Problems (Hungarian method), Dynamic Programming.

Queuing Theory and Simulations: Queuing Theory (Characteristics, models, and applications in service systems), Inventory Management (EOQ model, safety stock, and reorder point calculations), Introduction to Monte Carlo simulation.

Network Models and Project Management: Introduction to network analysis, Construction of network diagrams (PERT/CPM), Time estimation, critical path, slack time, Crashing of projects and cost-time trade-off.

Text Books:

1. Hamdy A. Taha, *Operations Research: An Introduction*, Pearson, 10th Edition.

Reference Books:

1. Michael Carter, Camille C. Price, Ghaith Rabadi, *Operations Research: A Practical Introduction*, CRC Press, 2nd Edition.

ME 4757 **3-0-0-3**

Smart Materials

Prerequisite: NA

Course Outcomes:

CO1	To make use of various smart materials properties for sensors and actuators applications.
CO2	To understand the working of sensors for various applications.

CO3	To identify the suitable actuators for corresponding applications.
CO4	To model the piezoelectric effect for energy harvesting and demonstrate the measurement and signal processing techniques for structural dynamics testing.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction to Smart Materials, Structures and Products Technologies - Smart materials (Physical Properties) Piezoelectric Materials, Elecrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials, Magnetorheological Fluids, Electrorheological Fluids, Shape Memory Materials.

Smart Sensors and Technologies - Smart Sensors: Accelerometers - Force Sensors- Load Cells, Torque Sensors, Pressure Sensors, Microphones, Impact Hammers- MEMS Sensors

– Fiber Optic Sensors.

Smart Actuator and its Techniques – Role of Actuators and Actuator materials – Piezoelectric and Electrostrictive Materials – Magneto-structural Materials – Shape Memory Alloys – Electro rheological fluids – Electromagnetic actuation

Introduction to Piezoelectric Energy harvesting - Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modelling - piezoelectric generators, Piezoelectric energy harvesting applications.

Measurement and Signal Processing Techniques – Static and Dynamic Measurement Methods-Signal conditioning devices; Structural dynamics and Identification techniques; Passive, Semi -active and Active control; Feedback and feed forward/control strategies.

Text Books:

1. Gandhi, M. V. and Thompson B.S., *Smart Materials and Structures*, Chapman and Hall, London, 1st Edition.
2. Srinivasan, A. V. and Michael McFarland, D., *Smart Structures: Analysis and Design*, Cambridge University Press, 1st Edition

Reference Books:

1. Michelle Addington and Daniel L. Schodek, S*mart Materials and Technologies, For the Architecture and Design Professions,* Routledge, 2nd Edition.

ME 4758 **3-0-0-3**

Electric Vehicle Control Systems

Prerequisite: NA

Course Outcomes:

CO1	To gain a comprehensive understanding of the components and control principles of electric vehicles.
CO2	To control various types of electric motors used in EVs, including the use of advanced control techniques.
CO3	To design and implement battery management systems, ensuring safety and efficiency.
CO4	To integrate advanced control systems in EVs including vehicle dynamics, autonomous driving, and energy management.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Overview of electric vehicle systems and sub-systems, EV powertrain architecture and control loops, Role of embedded systems and microcontrollers, CAN communication and networking in EVs, Functional safety.

Electric Motor Control: Types of electric motors used, Motor control techniques: scalar and vector control (FOC), Inverter operation and PWM control, Regenerative braking and torque control strategies.

Battery Management and Charging Control: Battery characteristics and models, Battery Management Systems (BMS), State-of-Charge (SOC) and State-of-Health (SOH) estimation, Thermal management

Advanced Control Systems and Integration: Vehicle Dynamics Control (Traction control, stability control, and torque vectoring), Autonomous and Connected EVs: control systems, Future Trends and Innovations.

Text Books:

1. K.C.Jain, Amit R.Patil, Arvind J. Bhosale, S.S. Raghuvanshi, *Fundamentals of Hybrid and Electric Vehicles*, Khanna Publishers, London, 1st Edition.

Reference Books:

1. Austin Hughes, Bill Drury, D., *Electric Motors and Drives: Fundamentals, Types and Applications*, Newnes, 4th Edition.

Syllabus of Open Elective II Courses

ME 4850 **3-0-0-6**

Energy Storage Technologies

Prerequisite: Engineering Mathematics-II (MA 1201)

Course Outcomes:

CO1	Describe the importance, classification, and application areas of different energy storage technologies.
CO2	Analyze and compare thermal and chemical storage systems in terms of efficiency, materials used, and applications.
CO3	Explain the operating principles and characteristics of batteries, supercapacitors, and fuel cells.
CO4	Design basic battery systems for electric vehicles considering thermal management, safety, and lifecycle parameters.
CO5	Assess the feasibility and performance of storage systems for integration into power and transportation sectors.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	2	2	-	-	-	-	-	-	3	2
CO3	3	3	3	2	2	-	-	-	-	-	-	3	2
CO4	3	3	3	2	2	-	-	-	-	-	-	3	2
CO5	3	3	3	2	2	-	-	-	-	-	-	3	2

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Energy storage systems overview – Scope, needs and opportunities, technology overview and key disciplines, comparison of time scale of storages and applications, energy storage in the power and transportation sectors, importance in electric vehicles, current electric vehicle market.

Thermal storage systems – Heat pumps, hot water storage tanks, solar thermal collectors, application of phase change materials (PCMs), types of PCMs (organic and inorganic), efficiencies and economic evaluation.

Chemical storage systems – Hydrogen, methane; chemical storage of solar energy; applications, advantages and limitations, challenges and future prospects.

Electromagnetic storage systems – Double-layer capacitors, superconducting magnetic energy storage (SMES), concepts, advantages, limitations, and future prospects.

Electrochemical storage systems - (a) Batteries: Working principle, primary and secondary (flow) batteries, battery chemistries (Li-ion, metal hydride vs. lead-acid), performance evaluation. (b) Supercapacitors: Working principles, types, cycling and performance, comparison with batteries, hybrid supercapacitors. (c) Fuel cells: Operational principles, types, hybrid systems with batteries and supercapacitors

Battery design for transportation – Mechanical design and packaging of battery packs, quick chargers, optimization methods, thermal runaway, battery thermal management, battery recycling.

Text Books:

1. Ralph Zito, *Energy Storage: A New Approach*, Wiley, 1st Edition ,2010.
2. Robert A. Huggins, *Energy Storage*, Springer Science & Business Media, 1st Edition, 2010.

Reference Books:

1. Gianfranco Pistoia and Boryann Liaw, *Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost*, Springer International Publishing, 1st Edition, 2018.

ME 4851 **3-0-0-3**

Total Quality Management

Prerequisite: NA

Course Outcomes:

CO1	Understand the fundamentals of quality management practices.
CO2	Understand quality management philosophies, techniques, and frameworks
CO3	Discuss the need of customer expectations, employee involvement and supplier partnership.
CO4	Adopt TQM methodologies for continuous quality improvement

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Dimensions of Quality, Quality Planning, Quality Costs and Analysis, Axioms of TQM. Contribution of Quality Gurus: Shewhart SPC, Deming Philosophy, Juran Trilogy, Crosby zero Defect Philosophy, Barriers to TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.

TQM Principles: Customer satisfaction - Customer Perception of Quality, Customer Complaints, Service Quality. Customer Retention, Employee Involvement - Motivation, Empowerment teams, Continuous Process Improvement - Juran Trilogy, PDSA Cycle, Kaizen, Supplier Partnership, Performance Measures, Case studies.

TQM Tools: Benchmarking, Quality Function Deployment (QFD) - House of Quality, Taguchi Robust Design Concept, Total Productive Maintenance (TPM), FMEA, The seven tools of quality, Process capability, Concept of six sigma, New seven management tools, Case studies.

Quality Systems: Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System - Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 - Concept, Requirements and Benefits, Case Studies.

Text Books:

1. Dale H.Besterfiled, *Total Quality Management*, Pearson Education, Delhi, 4th Edition, 2015.
2. Subburaj Ramasamy, *Total Quality Management*, Tata McGraw Hill Ltd., 1st Edition, 2025.
3. Narayana V and Sreenivasan N.S., *Quality Management - Concepts and Tasks*, New Age International, Delhi, 1st Edition,1996.

Reference Books:

1. Mitra A, *Fundamental of Quality Control and Improvement*, PHI, 3rd Edition, 2008.

2. Juran J M and Gryna F M, *Quality Planning and Analysis*, Tata McGraw Hill, 4th Edition, 2001.
3. Jain, Quality Control and Total Quality Management, Khanna Publications, New Delhi, 1st Edition, 2001.

ME 4852 **3-0-0-3**

Computer Aided Geometric Design

Prerequisite: NA

Elements of Product Design Course Outcomes:

CO1	To introduce the basic terminologies and the mathematical definitions
CO2	To be able to understand Bezier and Spline curves and its formulations
CO3	To be able to understand surface representations and its formulations
CO4	To be able to understand solid representations and its formulations

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction
Intoduction to Geometric Modeling - Affine and convex combination, Intoduction to Equations - Implicit, explicit, parametric, Cubic Hermite curves - Algebraic and geometric form, Blending functions, Subdivision, Reparameterization and Composite Hermite curves (C^n and G^n continuity).

Bezier curves - Control polygons and Bernstein basis, DeCasteljau algorithm, First and second derivatives at the ends, Continuity aspects, B-Spline Curves - periodic, open and non-uniform knot vectors and corresponding curves, Rational B-splines, NURBS, and Quadratic variety, Transformations in 2D and 3D, affine transformation.

Hermite Surface - Algebraic and geometric form, Subdivision and Reparameterization, Continuity of surfaces

Bezier surface - Control net representation, Direct and indirect DeCasteljau algorithm for Bezier surface, Continuity aspects.

B-Spline Surfaces - periodic, open and non-uniform knot vectors and corresponding surfaces, Rational B-splines, NURBS. Introduction to Solid Modeling - Topology of surfaces, Euler and modified form of equations.

Representations - Quadtree, Octree, Halfspace, Boundary Representation (B-Rep), Constructive Solid Geometry (CSG)

Text Books:

1. Michael E. Mortenson, Maria C., *Yang, Geometric Modeling*, John Wiley & Sons, 2nd Edition, 1997
2. David Rogers and J., *Mathematical Elements for Computer Graphics*, McGraw Hill Education, 2nd Edition, 2017.

Reference Books:

1. Gerald Farin, *Curves and Surfaces for CAGD: A Practical Guide*, Morgan Kaufmann Publishers, 5th Edition, 2001.

ME 4853 **3-0-0-3**

Introduction to Micro Electro Mechanical Systems

Prerequisite: NA

Course Outcomes:

CO1	To get familiarize with MEMS and its engineering application
CO2	To understand the working principle and mechanisms in MEMS devices
CO3	To understand the various fabrication processes involved
CO4	To understand the various design aspects of MEMS and its packaging

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Definition of MEMS. MEMS devices. Silicon as a MEMS material – mechanical properties of silicon. Mechanical components in MEMS. Design concepts of mechanical components.

Working Principles of Microsystems. Engineering Science for Microsystems design and Fabrication. Scaling laws – Scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity-fluid mechanics and heat transfer.

Materials for MEMS and Microsystems. Fabrication technologies – Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapor Deposition – Etching, Micro manufacturing – Bulk and surface micro machining – LIGA

Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly – Selection of Packaging Materials.

Text Books:

1. Tai–Ran Hsu, *MEMS & Microsystems Design and Manufacturing*, John Wiley & Sons, 2nd Edition, 2008.

Reference Books:

1. Mohamed Gad-el-Hak*: The MEMS Handbook*, CRC Press, 2nd Edition,2017
2. Marc J. Madou, *Fundamentals of Microfabrication*, CRC Press, 2nd Edition, 2018.

ME 4854 **3-0-0-3**

Supply Chain Management

Prerequisite: NA

Course Outcomes:

CO1	Understand the nature of supply chains and trace the historical perspective, leading to their development and growth, it identify the goal of a supply chain and find out the impact of supply chain decision on the success of the firm.
CO2	Design distribution network with strength and weakness of various distribution options of SCM. Synthesize different real life cases and establish strategic fit between the supply chain strategy and the competitive strategy.

CO3	Understand drivers of supply chain performance, Analyse factors influencing network design and forecasting in a supply chain.
CO4	Understand the role of aggregate planning, inventory, IT and coordination in a supply chain.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit. Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.

Emerging Trends and Innovations in Supply Chain Management: Digital transformation and technology in supply chains, Role of IoT, Big Data, and AI in supply chain management sustainability and resilience in supply chains, Global strategies and risk management.

Text Books:

1. Sunil Chopra and Peter Meindl, *Supply Chain Management - Strategy, Planning and Operation,* Pearson Education Asia, 7th Edition,2021.
2. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, *Designing and Managing the Supply Chain - Concepts Strategies and Case Studies,* Tata-McGraw Hill, 3rd Edition, 2007.

Reference Books:

1. John J Coyle, *Managing Supply Chains: A Logistics Approach*, Cengage Learning, 10th Edition,2019
2. Jeremy F Shapiro, George Nikolakopoulos, *Modelling the Supply Chain*, Cengage Learning, 3rd Edition,2019.

ME 4855 **3-0-0-3**

Introduction to Design Thinking

Prerequisite: NA

Course Outcomes:

CO1	Interpret the relationship between R&D and innovation Strategies
CO2	Formulate pathways for New Product Development
CO3	Understand the different strategic alliances and firm's intellectual property rights.
CO4	Understand the types and models of innovation and the frameworks of innovation

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

What is Different About Design thinking? Design Thinking Skills Principles of Design Thinking, Iterating ideas, The Basis for Design Thinking, The Design Thinking Team, Design Thinking Workshops and Meetings.

Listening and Empathizing Techniques – observation – structured open ended approach - , Design Thinking Frameworks, Ideation tools – brainstorming, innovation heuristics, behavior models, overcoming cognitive fixedness.
Use of Diagrams and Maps in Design Thinking – Empathy map. Affinity diagram, mind map, journey map, combining ideas into complex innovation concepts.

Design Thinking in Information Technology, Design in IT Industry, Agile software Developments in Virtual Collaborative Environments, process, Design Thinking in IT Industry and Business process modelling, Approaches to Combine Design and Development Activities. Multi-User, Multi-Account Screen Interaction.

Titles Toolkit Story telling – improvisation, scenario planning, development of scenarios, evaluation tools, frog design and prototyping - – Exercises and case-based discussions, Assess developer and user perspectives for bias – apply frameworks to strengthen communication – sustain a culture of innovation.

Text Books:

1. Idris Mootee, *Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School*, John Wiley & Sons, 1st Edition.
2. Tim Brown, *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*, HarperCollins Publishers Ltd, 1st Edition

Reference Books:

1. Jeanne Liedtka, Andrew King, and Kevin Bennett, *Solving Problems with Design Thinking*, Columbia Business School Publishing, 1st Edition, 2013
2. Christoph Meinel, Larry Leifer and Hasso Plattner, *Design Thinking : Understand – Improve – Apply*, Springer Berlin, Heidelberg, 1st Edition, 2013.

ME 4856 **3-0-0-3**

Industry 4.0

Prerequisite: NA

Course Outcomes:

CO1	To recognize need and trends of Industry 4.0.
CO2	To understand concepts and technologies supporting Industry 4.0.
CO3	To explore challenges and industrial applications of Industry 4.0.
CO4	Understand cyber physical system and the emerging applications.
CO5	Implement the industry 4.0 to solve engineering problems.

Course Articulation Matrix:

COs	**POs**											**PSOs**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2

CO1	2	1	-	-	1	-	-	-	-	-	-	3	2
CO2	3	2	-	-	2	-	-	-	-	-	-	3	2
CO3	2	3	1	2	2	-	-	-	-	-	-	3	2
CO4	3	2	1	2	3	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	3	2

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Overview History – Industrial Revolution - Introduction to Industry 4.0 - Profound and Systematic Change – Trends In Industry 4.0

Industry 4.0: Sustainability Assessment of Manufacturing Industry Sustainability – Supply Chain Management- Information and Communication Technology- Introduction To Emerging Issues.

Industry 4.0: Lean Production System Lean Production System – Types of Waste- Significance of Learn production system
Industry 4.0 Concepts & Principles: Introduction, Robotics, Autonomous vehicles -AI, Cyber physical System, Cloud computing, machine learning.

Industry 4.0: Smart Factories Introduction to Smart Factories – Need of Smart Factory- Components of Smart Factory, Significance of Ergonomics in industry 4.0, Case studies.

Text Books:

1. Klaus Schwab, *The Fourth Industrial Revolution*, Portfolio Penguin, 1st Edition,2016.
2. Alasdair Gilchrist, *Industry 4.0: The Industrial Internet of Things,* Apress, 1st Edition, 2016

Reference Books:

1. N A Siddiqui, *Operations Research: Introduction to Six Sigma*, New Age International Private Limited, 1st Edition 2016

ME 4857 **3-0-0-3**

Energy Audit and Energy Management

Prerequisite: NA

Course Outcomes:

CO1	To gain an understanding of the fundamental principles and strategies of energy management.

CO2	To conduct various types of energy audits, utilizing appropriate methodologies and instruments.
CO3	To identify and implement energy efficiency and conservation measures in buildings and industrial settings.
CO4	To apply economic and policy aspects to implement sustainable energy practices.

Course Articulation Matrix:

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

1 – Low 2 – Medium 3 – High

Detailed Syllabus:

Introduction: Fundamentals of energy management and energy conservation, Energy scenario at national and global level, Energy Management Strategies.

Energy Efficiency in Thermal and Electrical Utilities: Waste Heat Recovery, Cogeneration, Energy Conservation in Buildings and ECBC, Energy Efficiency Technologies.

Energy Audit: The energy audit concept. Elements of energy audit, Presentation of energy audit report. Analysis of energy audit report of residential areas and various industries.

Government Policies and Regulations: Laws And Acts of Electricity in India, Regulations, State Governments Policies.

Text Books:

1. L. Ashok Kumar, Gokul Ganesan, *Energy Audit and Management*, CRC Press, 1st Edition.

Reference Books:

1. Stephen A. Roosa, Steve Doty, Wayne C. Turner, *Energy management handbook, Routledge*, Taylor & Francis, 9th Edition.