CURRICULUM & SYLLABI

for

B. Tech Programme

in

Mechanical Engineering

(2024 Onwards)

DEPARTMENT OF MECHANICAL ENGINEERING

National Institute of Technology Manipur

Langol, Imphal- 795004

India

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	1	2	0	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	1	0	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 Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 2301	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Materials Engineering (ME 2301)		
Course Objectives	• To acquire sound knowledge on phase diagram • To understand the heat treatment of materials and influence of material processing on the material properties. • To deepen the knowledge about stress-strain curves and metal plasticity. • To understand the various material testing methods.		

Course Outcomes		**Cognitive Levels**
CO1	To acquire sound knowledge on phase diagram and heat treatment of materials	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand the influence of material processing on the material properties	Knowledge/Analysis (Level-I/Level-IV)
CO3	To deepen the knowledge about stress-strain curves and metal plasticity	Application/Analysis (Level-III/Level-IV)
CO4	To understand the various material testing methods.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**III**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Introduction to Physical Metallurgy
	Author	Avner, S.H
	Publisher	McGraw Hill Education
	Edition	2nd Edition
2.	Title	Mechanical Metallurgy
	Author	Dieter, G.E
	Publisher	McGraw Hill Education
	Edition	2nd Edition

Reference Books		
1.	Title	Physical Metallurgy
	Author	V. Singh,
	Publisher	Standard Publishers
	Edition	2nd Edition

Course Contents		
	UNIT I: **Atomic Arrangement and Phase Diagrams** - Structure of metals and alloys: Phase diagram: phase rules. Phase Diagrams and Ferrous Alloys Fe- FeC diagram.	**10**
	UNIT II: Critical temperature - Plain carbon steel and other steels. Heat Treatment of steel, CCT diagrams, austempering, martempering, ausform-	**8**

	ing. Surface hardening process - non - ferrous alloys.	
	UNIT III: 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.	**8**
	UNIT IV: 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.	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 2302	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Engineering Thermodynamics (ME 2302)		
Course Objectives	By the end of this course, students will: • Understand fundamental thermodynamic concepts, laws, and properties. • Analyze energy transfer via work, heat, and mass in systems. • Apply the first law of thermodynamics to analyze energy conservation in closed and open systems. • Apply the second laws of thermodynamics to engineering systems. • Analyze thermodynamic cycles (e.g., Carnot, Rankine, refrigeration) for efficiency and performance. • Utilize thermodynamic tables, charts, and equations of state for problem-solving.		

Course Outcomes		**Cognitive Levels**
CO1	Explain fundamental thermodynamic concepts, including systems, equilibrium, properties, and the Zeroth Law.	Comprehension (Level II)
CO2	Apply the First Law of Thermodynamics to analyze energy conservation in closed and open systems.	Application (Level III)
CO3	Use thermodynamic tables, diagrams, and equations of state to determine properties of pure substances.	Application (Level III)
CO4	Analyze the Second Law of Thermodynamics to evaluate process reversibility, entropy generation, and cycle efficiency.	Analysis (Level IV)
CO5	Explain fundamental various thermodynamic cycles	Comprehension (Level II)

Semester	**III**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**

	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Thermodynamics: An Engineering Approach			
	Author	Cengel, Y. A., Boles, M. A.			
	Publisher	McGraw Hill Education			
	Edition	9th Edition			
2.	Title	Fundamentals of Thermodynamics			
	Author	Borgnakke, C., and Sonntag, R. E.			
	Publisher	John Wiley & Sons			
	Edition	10th Edition			
Reference Books					
1.	Title	Engineering Thermodynamics			
	Author	P. K. Nag,			
	Publisher	McGraw Hill Education			
	Edition	6th Edition			
Course Contents	**UNIT I – INTRODUCTION AND BASIC CONCEPTS**: Thermodynamics definitions, systems (closed, open, isolated), properties of systems (intensive, extensive), state, equilibrium, and processes, temperature and the Zeroth law of thermodynamics, pressure and units, forms of energy (internal, kinetic, potential), energy transfer by heat and work, mechanical forms of work (boundary, shaft, spring, etc.), first law of thermodynamics, energy balance and efficiency.				**5**
	UNIT II - PROPERTIES OF PURE SUBSTANCES: Pure substances and phase changes, property diagrams (P-V, T-V, P-T, etc.), thermodynamic tables (saturation, superheated, compressed liquid), ideal gas equation of state and compressibility factor.				**6**
	UNIT III - ENERGY ANALYSIS OF CLOSED AND OPEN SYSTEMS: Moving boundary work, energy balance for constant-pressure and constant-volume processes, specific heats and internal energy/enthalpy changes, applications to real-world systems, conservation of mass for steady and unsteady flow processes, flow work and energy transfer in control volumes, steady-flow devices (nozzles, diffusers, turbines, compressors, etc.), energy analysis of throttling devices and mixing chambers.				**10**
	UNIT IV - THE SECOND LAW OF THERMODYNAMICS AND ENTROPY: Thermal energy reservoirs and heat engines, refrigerators and heat pumps, statements of the second law (Kelvin-Planck, Clausius), reversible and irreversible processes, Carnot cycle and Carnot efficiency, definition and physical, interpretation of entropy, entropy change in pure substances, isentropic processes, entropy balance for closed and open systems, principle of entropy increase.				**11**

	UNIT V – THERMODYNAMIC CYCLES: Power cycles (heat engines) - Carnot cycle (ideal reversible cycle), Rankine cycle (steam power plants), Otto cycle (spark-ignition engines), diesel cycle (compression-ignition engines), Brayton cycle (gas turbines & jet engines), refrigeration & heat pump cycles - reversed Carnot cycle, vapor-compression refrigeration cycle.	**4**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 2303	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Mechanics of Deformable Bodies (ME 2303)		
Course Objectives	• To understand the fundamentals of stress and strain and the concept of strain energy. • Develop and formulate the hoop, radial, and longitudinal stresses in thin and thick cylindrical and spherical shells subjected to internal pressures. • To draw shear force and bending moment diagrams for beams subjected to different types of loads. • To understand the theory of simple bending and torsion of shafts and buckling of columns.		

Course Outcomes		**Cognitive Levels**
CO1	Evaluate the strength of various structural elements based on internal forces such as compression, tension, shear, bending, and torsion.	Knowledge/Evaluation (Level I/Level-VI)
CO2	Evaluate the behavior and strength of structural elements under the action of compound stresses and thus understand failure concepts.	Application/Evaluation (Level-III/Level-VI)
CO3	Analyse the basic concept and design of structural members subjected to bending moment and torsion.	Knowledge/Analysis (Level-I/Level-IV)
CO4	Understand the basic concept of strain energy stored in material under gradual load, impact load and suddenly applied load.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Analysis and design of structural elements such as columns and struts.	Comprehension/Analysis (Level-II/Level-IV)

Semester	**III**	**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	2	5	48
Prerequisite course codes with course names	Engineering Mechanics (ME 1101)				

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Text Books			
1.	Title	Mechanics of Materials	
	Author	Timoshenko, S.P., Gere, M.J.	
	Publisher	C.B.S. Publishers, 2011	
	Edition	2nd Edition	
2.	Title	Engineering Mechanics of Solids	
	Author	E. P. Popov	
	Publisher	Pearson Education, 2015	
	Edition	2nd Edition	
Reference Books			
1.	Title	Strength of Materials, Part I (Element Theory and Problems)	
	Author	S. Timoshenko	
	Publisher	CBS Publishers, 2021	
	Edition	3rd Edition	
2.	Title	Advanced Mechanics of Solids	
	Author	L.S Srinath	
	Publisher	McGraw Hill Education, 2017	
	Edition	3rd Edition	
3.	Title	Mechanics of Structures	
	Author	S. B. Junarkar	
	Publisher	Charotar Publishers, 2012	
	Edition	1st Edition	
Course Contents	**UNIT I**: **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.		**10**
	UNIT II: 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.		**6**
	UNIT III: 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.		**8**
	UNIT IV: 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.		**6**

	UNIT V: 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.		**6**
Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%	

MECHANICS OF DEFORMABLE BODIES LAB

LIST OF EXPERIMENTS

Sl. No.	**Experiments**
1	To study Brinell Hardness Testing machine & to perform Brinell Hardness Test
2	To study Rockwell Hardness Testing machine & to perform Rockwell Hardness Test
3	To study Vickers Hardness Testing machine & to perform Vickers Hardness Test
4	To study the Universal Testing machine and perform the tensile test.
5	To study the Torsion Testing machine & to perform the torsion test
6	To study the impact testing machine & perform the impact test (Izod & Charpy)
7	To find the compressive strength of a given specimen
8	Stress strain analysis on a thin walled cylinder
9	Stress strain analysis on a thick walled cylinder
10	To study the influence of rod length on buckling behaviour
11	To study the failure of and specimen by fatigue
12	To study the shear force diagram for a beam with two supports under a) Single point load at x=L/2 b) Symmetric loading with two equal loads F at x=L/2 and the other at x=3L/4. c) Eccentric loading with a point load F at x=L/4.
13	To study the stresses developed due to loading in a transparent specimen by photo elasticity method

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 2304	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Fluid Mechanics (ME 2304)		
Course Objectives	• To understand fluid properties and principles of pressure measurement. • To analyze hydrostatics, buoyancy, and stability of floating bodies. • To study fluid flow kinematics and apply Bernoulli's and Euler's equations. • To evaluate flow through orifices and notches and compute discharge. • To distinguish between laminar and turbulent flow and analyze pipe losses. • To apply dimensional analysis and model laws to fluid problems. • To analyze flow through pipes and open channels, including energy losses and hydraulic jumps.		

Course Outcomes		**Cognitive Levels**
CO1	Explain the fundamental properties of fluids and various pressure measurement techniques using manometers and mechanical gauges.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Determine forces on submerged surfaces and analyze buoyancy, flotation, and stability of floating bodies.	Application/Analysis (Level-III/Level-IV)
CO3	Classify different types of fluid flows and apply kinematic concepts including stream function and velocity potential.	Analysis/Synthesis (Level-IV/Level-V)
CO4	Apply Bernoulli's equation and analyze flow measuring devices such as Venturimeter, orifice-meter, and Pitot tube.	Evaluation/Analysis (Level-V/Level-IV)
CO5	Compute flow rates and discharge through orifices and notches, and estimate the time required for emptying tanks.	Evaluation/Analysis (Level-V/Level-IV)
CO6	Analyze laminar and turbulent flow through pipes using governing equations and empirical correlations, including Reynold's and Prandtl's theories.	Evaluation/Analysis (Level-V/Level-IV)
CO7	Utilize dimensional analysis and model laws to design scaled models and interpret flow behavior in pipe and open channel systems.	Evaluation/Analysis (Level-V/Level-IV)

Semester	**III**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	2	5	48
Prerequisite course codes with course names	Engineering Mathematics-III (MA 2301)				

Text Books		
1.	Title	Fluid Mechanics: Fundamentals & Applications (SI Units)
	Author	Yunus A. Çengel
	Publisher	Tata McGraw- Hill

	Edition	4th Edition	
2.	Title	Introduction to Fluid Mechanics and Fluid Machines	
	Author	S. K. Som, G. Biswas, S. Chakraborty	
	Publisher	Tata McGraw Hill Education Private Limited	
	Edition	3rd Edition	
Reference Books			
1.	Title	Fluid Mechanics	
	Author	Frank M. White	
	Publisher	McGraw-Hill Education	
	Edition	8th Edition	
Course Contents	**UNIT I**: 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.		**4**
	UNIT II: 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, Meta centre and metacentric height and equilibrium of floating bodies, period of oscillation.		**4**
	UNIT III: 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.		**8**
	UNIT IV: 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.		**4**
	UNIT V: 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.		**4**
	UNIT VI: 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.		**4**
	UNIT VII: 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		**8**

	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.	
Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

FLUID MACHINES LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	To determine the coefficient of discharge and calibration of the given Triangular Notch
2.	To determine the discharge coefficient of the given Rectangular notch.
3.	To determine the coefficient of discharge and calibration of the Orificemeter
4.	To determine of the coefficient of discharge and calibration of the Venturimeter
5.	To determine Chezy's constant and Darcy's coefficient on the pipe friction apparatus
6.	To determine the metacentric height and radius of gyration of
7.	Verification of Bernoulli's theorem experimentally.
8.	To determine the minor losses in pipes
9.	Study of flow measuring equipment – Pitot tube, Venturimeter, Orifice meter, Rotameter
10.	To determine the friction factor as a function of Reynolds number in pipe flow

Course Code: ME 2305	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Machine Drawing (ME 2305)		
Course Objectives	1. Applying standard drawing practices using fits and tolerances. 2. Modeling orthogonal views of machine components and assembly. -NIL- 3. Preparing standard drawing layout for modeled parts or assemblies with BoM. 4. Exposing the student to contemporary computer design tools for aerospace and mechanical engineers.		

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Outcomes		**Cognitive Levels**
CO1	Identify the national and international standards pertaining to machine drawing.	Analysis/Comprehension (Level IV/Level-II)
CO2	Apply limits and tolerances to assemblies and choose appropriate fits.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Recognize machining and surface finish symbols.	Application/Analysis (Level-III/Level-IV)
CO4	Explain the functional and manufacturing datum	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Illustrate various machine components through drawings	Application/Analysis (Level-III/Level-IV)

Semester	**III**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	1	2	0	3	36
Prerequisite course codes with course names	Engineering Drawing (ME 1149)				

Text Books		
1.	Title	A Text Book of Machine Drawing
	Author	Dhawan, R.K.
	Publisher	S. Chand & Company, 1998
	Edition	1st Edition
2.	Title	Engineering Drawing with CAD Applications
	Author	Ostrowsky, O.
	Publisher	Routledge, 1995
	Edition	1st Edition
3.	Title	Machine Drawing
	Author	Bhatt, N.D.
	Publisher	Charotar Publishing House, 2003.
	Edition	38th Edition
Reference Books		
1.	Title	Production Drawing
	Author	Kannaiah, P.
	Publisher	New Age International, 2014.
	Edition	3rd Edition
2.	Title	Textbook of Machine Drawing
	Author	V. Lakshmi Narayana and M. L. Mathur
	Publisher	M/s Jain Brothers, 2010.
	Edition	3rd Edition

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Contents	**UNIT I**: 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.	**8**
	UNIT II: 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.	**10**
	UNIT III: 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,	**10**
	UNIT IV: Tool post, Tool head for shaping machine, machine vice, screw jack. Industrial case study drawings in CAD.	**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 2401	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Applied Thermodynamics (ME 2401)		
Course Objectives	Upon completion of this course, students will be able to: • Analyze and compare thermodynamic cycles - evaluate the Carnot, Rankine, Brayton, Otto, Diesel, and Dual cycles, including their efficiency, limitations, and improvements (reheat, regeneration). • Explain supersaturated flow, nozzle design, and turbine classification (impulse/reaction), interpret velocity diagrams and analyze performance enhancement techniques (intercooling, reheat) in gas turbines. • Demonstrate knowledge of IC engines and combustion, differentiate between two-stroke and four-stroke SI/CI engines, analyze combustion processes (normal/abnormal) and performance metrics. • Evaluate reciprocating compressors, compute work input, efficiencies (volumetric, isothermal), and the effects of clearance volume, justify the use of multistage compression, intercooling, and optimum pressure ratios for minimizing work.		

Course Outcomes		**Cognitive Levels**
CO1	Analyze and compare thermodynamic cycles (Carnot, Rankine, Brayton, Otto, Diesel, Dual) for efficiency and	Analysis (Level IV)

	applications.	
CO2	Explain the working principles of steam/gas turbines and nozzles, including design and performance analysis.	Comprehension/Application (Level-II/Level-III)
CO3	Demonstrate knowledge of IC engine operation, combustion processes, and performance evaluation methods.	Application/Analysis (Level-III/Level-IV)
CO4	Evaluate reciprocating compressor performance and propose optimization techniques for minimal work input.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**IV**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	Engineering Thermodynamics (ME 2302)				

Text Books		
1.	Title	Applied Thermodynamics for Engineering Technologists
	Author	T. D. Eastop and A. McConkey
	Publisher	Longman Publishing Group
	Edition	5th Edition
2.	Title	Thermodynamics an engineering approach
	Author	Yunus A. Cengel and Michael A. Boles
	Publisher	Tata McGraw hill Pub
	Edition	6th Edition

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

Course Contents	**UNIT I - 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.	**10**
	UNIT II - 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.	**6**

	UNIT III - 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.	**10**
	UNIT IV - 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.	**10**

Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

APPLIED THERMODYNAMICS LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	Viscosity measurement using Ford open cup apparatus
2.	A study on internal combustion engines
3.	Performance characteristics of spark ignition (SI) engines
4.	Performance characteristics of compression ignition (CI) engines
5.	Emission measurement of IC engines
6.	Performance testing of single stage reciprocating air compressors
7.	Performance testing of double stage reciprocating air compressors
8.	Performance testing of centrifugal blower
9.	Performance testing of cooling towers
10.	Performance testing of Air conditioning system
11.	Performance testing of Refrigeration system
12.	Calorific value measurement of solids

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 2402	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Manufacturing Technology I (ME 2402)		
Course Objectives	• To learn about various casting, their working principles, types, and defects. • To learn about various welding methods their working principles, types, and defects. • To learn about various forming processes, such as forging, rolling, drawing, and sheet metal forming. • To learn about various extrusion processes and powder metallurgy.		

Course Outcomes		**Cognitive Levels**
CO1	The student will develop capability of selecting suitable manufacturing processes to manufacture the products optimally.	Analysis/Comprehension (Level IV/Level-II)
CO2	The student will be able to recommend the appropriate design of gating systems required in casting.	Knowledge/Analysis (Level-I/Level-IV)
CO3	The student will understand the different types of welding processes and shall be able to understand the advancements in welding techniques and bottlenecks encountered.	Application/Analysis (Level-III/Level-IV)
CO4	The student will understand the metal forming process.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**IV**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36

Prerequisite course codes with course names	NA

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

Reference Books		
1.	Title	Physical Metallurgy
	Author	V. Singh,
	Publisher	Standard Publishers
	Edition	2ndEdition

Course Contents	**UNIT I**: Introduction to manufacturing processes: Moulding materials and their requirements; Patterns: Types and various pattern materials. Casting	**12**

	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.	
	UNIT II: Metal joining processes: brazing, soldering, welding; Solid state welding methods; resistance welding; arc welding; submerged arc welding; inert gas welding; Welding defects, inspection.	**8**
	UNIT III: 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.	**8**
	UNIT IV: 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.	**8**

Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

MANUFACTURING TECHNOLOGY – I LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	To study and perform Arc welding with different types of welding joint.
2.	To study and perform Gas welding.
3.	To study and perform TIG & MIG welding
4.	To study and perform Submerged Arc Welding.
5.	To study and perform moulding sand casting
6.	To perform the sand compressive strength test.
7.	To perform the sand Tensile strength test.
8.	To perform the sand shear strength test.
9.	To perform sand mouldability test.
10.	To make pattern with the given dimension for sand casting.
11.	To perform sand casting.
12.	To perform simulation and analysis of casting using Z-Cast.

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 2403	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Fluid Machinery (ME 2403)		
Course Objectives	• To familiarize with the properties of fluids and the applications of fluid mechanic and fluid machines. • To formulate and analyze problems related to calculation of forces in different types of fluid machinery. • To classify fluid machinery and understand their principles and behavior of fluid flows. • To understand the principles of dimensional analysis in fluid machinery. • To familiarize with the construction and working of turbines and pumps and achieve the knowledge to test their performance.		

Course Outcomes		**Cognitive Levels**
CO1	Calculate forces and work done by a jet on fixed or moving plates and curved plates	Knowledge/Comprehension (Level-I/Level-II)
CO2	Explain the working of turbines and select a turbine for a specific application.	Application/Analysis (Level-III/Level-IV)
CO3	Analyse the working of air compressors and select the suitable one based on application requirements, pressure ratio, and efficiency considerations.	Analysis/Synthesis (Level-IV/Level-V)
CO4	Analyse gas turbines and identify the improvements in basic gas turbine cycles.	Analysis/Evaluation (Level-IV/Level-VI)
CO5	Explain the characteristics of centrifugal and reciprocating pumps	Application/Analysis (Level-III/Level-IV)

Semester	**IV**	**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	Fluid Mechanics (ME 2304)				

Text Books		
1.	Title	Fluid Mechanics and Thermodynamics of Turbomachines
	Author	S.L Dixon
	Publisher	Butterworth-Heinemann, 2005.
	Edition	5th Edition
2.	Title	Hydraulic and Compressible Flow Turbomachines
	Author	A.T Sayers
	Publisher	CBLS, 2003
	Edition	1st Edition
3	Title	A Textbook of Fluid Mechanics and Hydraulic Machines
	Author	R.K. Bansal,

	Publisher	Lakshmi Publications, 2010.	
	Edition	9th Edition	
Reference Books			
1.	Title	Gas Turbine Theory	
	Author	H.I.H Saravanamuttoo, G.F.C. Rogers and H. Cohen.	
	Publisher	Pearson	
	Edition	4th Ed.,2003	
2.	Title	Fluid Mechanics	
	Author	F. M. White	
	Publisher	Tata McGraw-Hill	
	Edition	6th Ed.,2008	
3.	Title	Introduction to Fluid Mechanics,	
	Author	R.W. Fox, A.T. McDonald and P.J. Pritchard	
	Publisher	John Wiley	
	Edition	6th Ed., 2004	
4.	Title	Fundamentals of Fluid Mechanics,	
	Author	B.R. Munson, D.F. Young, and T.H. Okhiishi	
	Publisher	Wiley India Edition	
	Edition	5th Ed.,2002	
5.	Title	Modern Compressible Flow,	
	Author	J. D. Anderson (Jr.),	
	Publisher	McGraw-Hill	
	Edition	International Ed., 1990.	
6.	Title	Fluid Mechanics	
	Author	Y. A. Cengel and J.M. Cimbala	
	Publisher	Tata McGraw-Hill	
	Edition	2006.	
7	Title	Gas Turbines,	
	Author	V Ganesan	
	Publisher	Tata McGraw-Hill	
	Edition	2nd Ed., 2003.	
Course Contents	**UNIT I**: Introduction - Classification - Dimensional analysis - Specific speed - Basic laws and equations. Hydraulic turbines; Pelton, Francis, and Kaplan turbines - Turbine efficiencies - Cavitation in turbines.		**10**
	UNIT II: Centrifugal Pumps: theory, components, and characteristics - Cavitation - Axial flow pumps - Pump system matching. Centrifugal and axial flow compressors; slip, surging and choking.		**12**
	UNIT III: 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 -		**14**

	Power and efficiency calculations. Combustion Chambers; Jet Propulsion	
Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

FLUID MACHINERY LAB

LIST OF EXPERIMENTS

Sl. No.	**Experiments**
1.	Performance test on the Pelton turbine
2.	Performance test on the Francis turbines
3.	Performance test on the Hydraulic Ram
4.	Study of Jet impact on flat and curved surfaces.

Course Code: ME 2404	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Kinematics of Machinery (ME 2404)		
Course Objectives	• To familiarize students with fundamental definitions, classifications, and types of mechanisms. • To analyze a mechanism for displacement, velocity, and acceleration at any point in a moving link. • To develop skills to design cam profiles for various follower motions. • To study the principles of gears and gear trains, including their design and relative motion analysis.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the principles of kinematic pairs, chains and their classification, degree of freedom, inversions, equivalent chains and planar mechanisms.	Knowledge/Analysis (Level I/Level-IV)
CO2	Analyze the planar mechanisms for position, velocity and acceleration.	Analysis/Comprehension (Level-IV/Level-II)
CO3	Synthesize planar four bar and slider crank mechanisms for specified design requirements.	Synthesis/Analysis (Level-V/Level-IV)
CO4	Design suitable gears for the given application.	Application/Evaluation (Level-III/Level-VI)

CO5	Synthesize cams and followers for specified motion profiles.				Synthesis/Evaluation (Level-V/Level-VI)
Semester	**IV**			**EVEN**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Engineering Mechanics (ME 1101)				

Text Books			
1.	Title	Theory of Machines and Mechanisms	
	Author	J. J Uicker (Jr), G. R Pennock and J. E Shigley,	
	Publisher	Oxford International Student Edition, 2009	
	Edition	3rd Edition	
2.	Title	Mechanism and Machine Theory	
	Author	J. S. Rao, R. V. Dukkipat	
	Publisher	New Age International, 2008	
	Edition	2nd Edition	
3.	Title	Theory of Machines	
	Author	S. S. Rattan	
	Publisher	Tata McGraw Hill, 2016	
	Edition	5th Edition	
Reference Books			
1.	Title	Theory of Mechanisms and Machines	
	Author	A.Ghosh and A. K. Mallik	
	Publisher	East West Press Pvt. Ltd, 2009	
	Edition	3rd Edition	
2.	Title	Theory of Machines	
	Author	S. S. Rattan	
	Publisher	Tata McGraw Hill, 2019	
	Edition	5th Edition	
3.	Title	Theory of Machines	
	Author	R.S. Khurmi and J.K. Gupta	
	Publisher	S. Chand Publishing, 2020	
	Edition	14th Edition	
Course Contents	**UNIT I**: **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.		**8**
	UNIT II: 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		**8**

	freedom mechanisms.	
	UNIT III: 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.	**12**
	UNIT IV: 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.	**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 2405	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Mechanical Measurements (ME 2405)		
Course Objectives	• To understand the Measurement standards and systems. • To understand and apply the calibration procedure of different instruments. • To classify various types and use of gauges, projectors, comparators and transducers • To understand the Nuclear, thermal radiation measurement and Issues in measuring thermophysical properties of micro and nano materials.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the measurement terminologies and the concept of a generalized measurement system.	Analysis/Comprehension (Level IV/Level-II)
CO2	Estimate errors and uncertainty in measurements using statistical analysis and analyze the zeroth, first, and second order measurement systems.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Select sensors for measurement of specific parameters with the required accuracy, and Calibrate measuring instruments with the given standards.	Application/Analysis (Level-III/Level-IV)
CO4	Design experiments by combining measuring devices to	Synthesis/Evaluation (Level-V/Level-VI)

	obtain the desired outputs.				
Semester	**IV**		**Even**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Experimental Methods for Engineers			
	Author	Holman, J.P.			
	Publisher	Tata McGraw Hill Book Company, New Delhi, 2010			
	Edition	10th Edition			
2.	Title	Mechanical Measurements			
	Author	Thomas G. Beckwith and Lewis Buck			
	Publisher	Narosa Publishing House, 2009.			
	Edition	4th Edition			
Reference Books					
1.	Title	Measurement Systems - Applications and Design.			
	Author	Ernest O. Doeblin			
	Publisher	Tata McGraw Hill Book Company, New Delhi, 2011			
	Edition	4th Edition			
2.	Title	Engineering Metrology			
	Author	Jain R K			
	Publisher	Khanna Publishers, Delhi, 1998			
	Edition	3rd Edition			
Course Contents	**UNIT I**: **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.				**10**
	UNIT II: 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.				**8**

	UNIT III: 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.	**10**
	UNIT IV: 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.	**8**

Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

MECHANICAL MEASUREMENTS LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	Calibration of Outside micrometer.
2.	Calibrations of Vernier height gauge.
3.	Calibration of Dial vernier caliper.
4.	Calibration of Vernier caliper.
5.	Measuring the Inside diameter by using inside micrometer.
6.	Measuring the angle by using Vernier bevel protector.
7.	Measuring the Angle by using Sine Bar.
8.	To measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper.
9.	To measure the angle of V- groove of a given V- Block by using two cylindrical rollers of different diameter.
10.	To calibrate the given Dial gauge with respect to a standard reference i.e. slip gauge set and draw the calibration curve.
11.	Measurement of central distance between two Holes.
12.	Measurement of Effective Diameter by using by Screw Thread micrometer.

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 3501	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Heat and Mass Transfer (ME 3501)		
Course Objectives	• Study the modes of heat transfer. • Learn how to formulate and solve 1-D steady and unsteady heat conduction problems. • Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems. • Study the basic principles of heat exchanger analysis and thermal design. • Understand the principles of boiling and condensation, including radiation heat transfer related engineering problems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the basic modes of heat transfer.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Interpret and compute forced and free convective heat transfer.	Application/Analysis (Level-III/Level-IV)
CO3	Compute temperature distribution in steady-state and unsteady-state heat conduction.	Analysis/Synthesis (Level-IV/Level-V)
CO4	Understand and interpret heat transfer through extended surfaces.	Knowledge/Analysis (Level-I/Level-IV)
CO5	Explain the Principles of radiation heat transfer and understand the numerical formula for heat conduction problems	Application/Analysis (Level-III/Level-IV)
CO6	Design heat exchangers using LMTD and NTU methods.	Application/Evaluation (Level-III/Level-VI)

Semester	**V**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	2	5	48
Prerequisite course codes with course names	Applied Thermodynamics (ME2401)				

Text Books		
1.	Title	Fundamentals of Heat and Mass Transfer
	Author	F.P Incorpera, D.P Dewitt
	Publisher	John Wiley,2002
	Edition	5th Edition
2	Title	Heat Transfer,
	Author	J.P Holman
	Publisher	Tata McGraw-Hill, 2004.
	Edition	9th Edition
Reference Books		

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

1.	Title	Heat Transfer - A Basic Approach	
	Author	M.N Ozisik	
	Publisher	McGraw-Hill, 1985.	
	Edition	1st Edition	
2.	Title	Heat Transfer - A Practical Approach	
	Author	Y.A Cengel	
	Publisher	McGraw-Hill, 1998.	
	Edition	1st Edition	
3.	Title	Convective Heat Transfer	
	Author	A Bejan	
	Publisher	John Wiley and Sons, 2004.	
	Edition	3rd Edition	
4.	Title	Principles of Heat Transfer	
	Author	F Kreith, M. S Von	
	Publisher	Brook and Cole Publication, 2001.	
	Edition	6th Edition	
Course Contents	**UNIT I**: Modes of heat transfer; Conduction: 1-D and 2-D steady conduction; 1-D unsteady conduction- Lumped capacitance and analytical methods.		**10**
	UNIT II: 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.		**8**
	UNIT III: Radiation: Stefan-Boltzmann law; Planck's law; emissivity and absorptivity; radiant exchange between black surfaces.		**8**
	UNIT IV: Heat exchangers: LMTD and e-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.		**10**
Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%	
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%	

HEAT AND MASS TRANSFER LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	Thermal Conductivity of Insulating Powder
2.	Thermal Conductivity of liquid
3.	Thermal conductivity of metal rod
4.	Stefan-Boltzmann constant of radiation
5.	Natural convention of pin fin
6.	Forced convection of pin fin
7.	Natural convection of vertical rod
8.	Forced convection in a pipe
9.	Parallel and counter-flow heat exchanger
10.	Thermal conductivity of the insulating rod

Course Code: ME 3502	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Manufacturing Technology II (ME 3502)		
Course Objectives	• **To understand the fundamental mechanics of metal cutting**, tool materials, tool geometry, chip formation, wear, and optimization strategies in machining. • **To study the working principles and operations of conventional machine tools** such as lathe, milling, shaping, slotting, drilling, and grinding machines, and their applications in batch production and CNC systems. • **To impart knowledge on tooling systems**, including the design and application of jigs, fixtures, and principles of location and clamping for enhanced manufacturing accuracy and efficiency. • **To explore advanced manufacturing techniques**, including unconventional machining methods, micro-finishing processes, rapid prototyping, and tooling technologies.		

Course Outcomes		**Cognitive Levels**
CO1	**Analyze and comprehend** the mechanics of metal cutting, tool wear, temperature, and tool life for improved machinability and surface finish.	Analysis/Comprehension (Level IV/Level-II)
CO2	**Identify and analyze** various machine tools and operations such as milling, turning, drilling, and grinding, and their role in modern manufacturing.	Knowledge/Analysis (Level-I/Level-IV)
CO3	**Apply and analyze** the design principles of jigs, fixtures, and clamping mechanisms used in batch production and CNC operations.	Application/Analysis (Level-III/Level-IV)
CO4	**Evaluate and synthesize** unconventional machining processes and rapid manufacturing techniques for precision	Synthesis/Evaluation (Level-V/Level-VI)

	and advanced material processing.				
Semester	**V**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Manufacturing Science,			
	Author	A Ghosh and A K Mallik			
	Publisher	Wiley Eastern			
	Edition	1986.			
2.	Title	Introduction To Machining Science,			
	Author	G K Lal			
	Publisher	New Age International Pvt. Ltd.			
	Edition	2007			
Reference Books					
1.	Title	Metal Cutting Principles			
	Author	M C Shaw			
	Publisher	MIT Press			
	Edition	2004			
Course Contents	**UNIT I**: Metal Cutting: Mechanics, tools (material, temperature, wear, and life considerations), geometry and chip formation; surface finish and machinability; optimization;				**10**
	UNIT II: 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;				**12**
	UNIT III: Tooling: Jigs and fixtures, principles of location and clamping; Batch production: CNC machines; Finishing: Micro finishing (honing, lapping, super finishing);				**6**
	UNIT IV: Unconventional methods: electro-chemical, electro-discharge, ultrasonic, LASER, electron beam, water jet machining etc.; Rapid prototyping and rapid tooling.				**8**
Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.		Continuous Evaluation 20% Mid Semester 30% End Semester 50%		
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be		Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%		

	considered.	

MANUFACTURING TECHNOLOGY – II LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	To study the details of Lathe machine.
2.	To study and making of different types of cutting tools.
3.	To perform step turning process, taper turning process and Knurling process with the given dimensions of job.
4.	To perform Threading process with the given dimensions of job.
5.	To study the details of Shaper Machine.
6.	To perform V-groove Cutting in shaper machine.
7.	To study the details of Gear Hobbing Machine.
8.	To perform gear Cutting in Gear Hobbing Machine.
9.	To Study and Perform CNC Lathe and CNC Milling
10.	To Study ECM and EDM.

Course Code: ME 3503	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Dynamics of Machinery (ME 3503)		
Course Objectives	• To understand the force-motion relationship of components subjected to external forces. • To analyze the force-motion characteristics of standard machine elements. • To study the undesirable effects of unbalances resulting from prescribed motions in mechanism. • To understand the importance of damping. • To reduce the physical vibratory system into spring and damping elements.		

Course Outcomes		**Cognitive Levels**
CO1	Impart knowledge on static and dynamic force analysis of mechanisms.	Knowledge/Analysis (Level I/Level-IV)
CO2	Characterize and design flywheels.	Analysis/Comprehension (Level-IV/Level-II)
CO3	Analyze the balancing of rotating and reciprocating parts in machines as well as analyze centrifugal governors.	Synthesis/Analysis (Level-V/Level-IV)
CO4	Illustrate the gyroscopic effects in ships, aero planes, and road vehicles.	Application/Evaluation (Level-III/Level-VI)
CO5	Understand free and forced vibrations of single degree freedom systems.	Knowledge/Application (Level-I/Level-III)

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Semester	**V**			**ODD**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	Engineering Mechanics (ME 1101) Kinematics of Machinery (ME 2404)				

Text Books		
1.	Title	Theory of Machines and Mechanisms
	Author	J. J Uicker (Jr), G. R Pennock and J. E Shigley,
	Publisher	Oxford International Student Edition, 2009
	Edition	3rd Edition
2.	Title	Mechanism and Machine Theory
	Author	J. S. Rao, R. V. Dukkipat
	Publisher	New Age International, 2008
	Edition	2nd Edition
Reference Books		
1.	Title	Kinematics, Dynamics, and Design of Machinery
	Author	K. J, Waldron and G. L Kinzel
	Publisher	Wiley Student Edition, 2004
	Edition	2ndEdition
2.	Title	Theory of Mechanisms and Machines
	Author	A. Ghosh and A. K. Mallik
	Publisher	East West Press Pvt. Ltd, 2009
	Edition	3rd Edition
3.	Title	Theory of Machines
	Author	S. S. Rattan
	Publisher	Tata McGraw Hill, 2009
	Edition	3rd Edition
4.	Title	Kinematics and Dynamics of Machinery
	Author	R. L. Norton
	Publisher	Tata McGraw Hill, 2009
	Edition	1st Edition
5.	Title	Mechanism Design, Analysis and Synthesis Volume 1
	Author	G. Erdman, G. N. Sandor, and Sridhar Kota
	Publisher	PHI, Inc., 2001
	Edition	4th Edition

Course Contents	**UNIT I**: **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.	**10**

	UNIT II: 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.	**10**
	UNIT III: 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.	**10**
	UNIT IV: 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.	**6**
Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

DYNAMICS OF MACHINERY LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	To perform experiment on Watt and Porter Governor.
2.	To perform experiment on Proell Governor.
3.	To perform experiment on Hartnell Governor.
4.	To determine Gyroscopic couple on Motorized Gyroscope.
5.	To perform the experiment for static balancing on static balancing machine.
6.	To perform the experiment for dynamic balancing on dynamic balancing machine.
7.	To determine the moment of inertia of connecting rod by compound pendulum method.
8.	To determine the moment of inertia of bar by Bi-Filer suspension
9.	To study the Torsional Vibrations of single rotor system
10.	To perform experiment on Cam and Follower Analysis apparatus
11.	To perform experiment on Coriollis component of acceleration apparatus
12.	To perform experiment on Epicyclic gear train apparatus
13.	To perform experiment on Slip and creep measurement apparatus
14.	To perform experiment on Journal bearing apparatus

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 3504	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Mechanical Vibrations (ME 3504)		
Course Objectives	• To understand the fundamentals of vibration. • To understand the concept of free and forced vibration of un-damped and damped systems. • To develop & formulate the two degrees of freedom systems. • To formulate the multi-degree of freedom systems. • To study and develop the vibrational equations of continuous systems.		

Course Outcomes		**Cognitive Levels**
CO1	Analyze the causes and effects of vibrations in mechanical systems and identify discrete and continuous systems.	Knowledge/Analysis (Level I/Level-IV)
CO2	Model the physical systems into schematic models and formulate the governing equations of motion.	Analysis/Comprehension (Level-IV/Level-II)
CO3	Compute the free and forced vibration responses of multi-degree of freedom systems through modal analysis and interpret the results.	Application/Analysis (Level-III/Level-IV)
CO4	Analyse and design systems involving unbalance, trans-missibility, vibration isolation, and absorption.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Analyse and design to control and reduce vibration effects in machinery.	Knowledge/Evaluation (Level-I/Level-VI)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	0	4	48
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Elements of Vibration Analysis
	Author	Lenord Meirovitch
	Publisher	McGraw Hill Ltd. 2007
	Edition	2nd Edition
2.	Title	Mechanical Vibrations
	Author	Rao, S.S
	Publisher	Pearson Education, 2017
	Edition	6th Edition
Reference Books		

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

1.	Title	Theory of Vibrations with Applications	
	Author	Thomson, W.T.	
	Publisher	Prentice Hall of India, 1999	
	Edition	5th Edition	
2.	Title	Vibration: Fundamentals and Practice	
	Author	Clarence W. de Silva	
	Publisher	CRC Press, 2006	
	Edition	2nd Edition	
Course Contents	**UNIT I**: **Fundamentals of Vibrations**- Introduction to vibrations: Causes, advantages, and disadvantages. Harmonic motion and Fourier series analysis. Elements of vibratory systems and natural frequency determination.		**6**
	UNIT II: **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.		**10**
	UNIT III: 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.		**10**
	UNIT IV: Continuous Systems- Vibrations of strings, rods, and beams. Natural frequencies and mode shapes. Approximate methods like Rayleigh-Ritz and Galerkin's method.		**10**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 3601	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Design of Machine Elements (ME 3601)		
Course Objectives	• To understand the fundamental concepts of designing machine elements, including factors influencing design and material selection based on mechanical properties. • To understand the modes of failure and theories of failure in mechanical systems. • To learn the design of the shafts, keys, couplings, and temporary as well as		

	permanent joints required to assemble the machine elements • To understand the concept of springs and bearings and their classifications.				
Course Outcomes					**Cognitive Levels**
CO1	Understanding the design function in mechanical engineering, the different steps involved in designing, and the relation of design activity with manufacturing activity				Knowledge/Comprehension (Level I/Level-II)
CO2	Ability to identify and understand failure modes and theories of failures for mechanical elements.				Analysis/Synthesis (Level-IV/Level-V)
CO3	Capable of designing shafts, keys, and couplings for industrial applications.				Application/Analysis (Level-III/Level-IV)
CO4	Capable of designing the temporary and permanent type joints in a mechanical system.				Analysis/Evaluation (Level-IV/Level-VI)
CO5	Analyse and design different types of spring and bearings.				Knowledge/Evaluation (Level-I/Level-VI)
Semester	**VI**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Mechanics of Deformable Bodies (ME 2303)				
Text Books					
1.	Title	Mechanical Engineering Design			
	Author	Richard G. Budynas, J Keith Nisbett, Shigley's			
	Publisher	McGraw Hill Ltd. 2011			
	Edition	9th Edition			
2.	Title	Design of Machine Elements			
	Author	V B Bhandari			
	Publisher	McGraw Hill Ltd. 2012			
	Edition	3rd Edition			
Reference Books					
1.	Title	Machine design an integrated approach			
	Author	Robert L Norton			
	Publisher	Pearson Education, 2009			
	Edition	2nd Edition			
2.	Title	Machine Design			
	Author	S G Kulkarni			
	Publisher	Tata McGraw Hill, New Delhi, 2008			
	Edition	1st Edition			
3.	Title	Machine Design			
	Author	R.S. Khurmi and J.K. Gupta			
	Publisher	S. Chand Publishing, 2005			
	Edition	14th Edition			
Course Contents	**UNIT I: Introduction**- Mechanical engineering design, Design considerations, Engineering material and its classification, Mechanical properties of				**8**

	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.	
	UNIT II: **Theories of failure**- Dilation - Distortion - Maximum Principal Stress Theory - Maximum Principal Strain Theory - Maximum Shear Stress Theory - Strain Energy Theory - Distortion energy theory.	**4**
	UNIT III: **Shafts and Couplings** -Design of solid and hollow shafts based on strength and rigidity, Keys, keyways, and splines, Design of rigid and flexible couplings.	**6**
	UNIT IV: 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.	**10**
	UNIT V: 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.	**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3602	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Mechatronics and Robotics (ME 3602)		
Course Objectives	• To introduce the components and principles of mechatronic systems, which integrate mechanical, electrical, and computational aspects. • To understand the principles and applications of various sensors, controllers, and actuators used in mechatronic systems. • To apply principles of mechanical and electrical engineering to the practice of engineering at the professional level in robotics, mechatronics, and related industries. • To explore the role of robotics and mechatronics in various industries and		

	emerging technologies.

Course Outcomes		**Cognitive Levels**
CO1	Model and analyze mechatronic systems for an engineering application.	Analysis/Comprehension (Level IV/Level-II)
CO2	Identify sensors, transducers and actuators for monitoring and controlling the behavior of processes and products.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Develop PLC programs for an engineering application.	Application/Analysis (Level-III/Level-IV)
CO4	Evaluate the performance of mechatronic systems.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Understand the application of various types of end effectors, sensor devices, homogeneous transformations and its applications in the analysis of a robotic structure and method of developing different types of mechanisms and kinematics of the robot	Synthesis/Evaluation (Level-V/Level-VI)
CO6	Understand robot programming languages which may be adopted in different applications, control motion mechanisms in all devices of robots	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VI**		**Even**	
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	1	2	5	48
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Mechatronics
	Author	Longman, W. Bolton
	Publisher	Addison Wesley Longman Ltd., 1999
	Edition	2nd Edition
2.	Title	Introduction to Mechatronics and Measurement systems
	Author	Alciatore David G and Histand Michael B
	Publisher	Tata McGraw Hill, 2012
	Edition	4th Edition.
3.	Title	Industrial Robotics
	Author	Mikell P. Groover
	Publisher	McGraw-Hill Education
	Edition	1st Edition, 1987
Reference Books		
1.	Title	Introduction to Robotics: Mechanics and Control
	Author	John J. Craig
	Publisher	Pearson Prentice Hall

	Edition	3rd Edition	
2.	Title	Mechatronics : A foundation course	
	Author	Clarence W. de Silva	
	Publisher	CRC Press, 2010.	
	Edition	1st Edition	
3.	Title	Mechatronics System Design	
	Author	Devdas Shetty and Richard, A. K., Vikas	
	Publisher	Publishing House Private Ltd., 2002.	
	Edition	1st Edition	
Course Contents	**UNIT I**: **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		**4**
	UNIT II: 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..		**10**
	UNIT III: 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.		**6**
	UNIT IV: 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		**6**
	UNIT V: 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		**10**
Course Assessment	Total Marks =100 Theory (75 Marks)	Continuous Evaluation 20% Mid Semester 30%	

	Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

MECHATRONICS AND ROBOTICS LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	To study the construction and working of a rotary and slider variable resistor.
2.	To study the construction and working of a Linear Variable Differential Transformer (LVDT)
3.	To study the construction and characteristics of a DC solenoid.
4.	To study the construction and characteristics of a DC relay.
5.	To study the construction and characteristics of a DC solenoid air valve.
6.	To study the construction and characteristics of a buzzer.
7.	To study the construction, principle and application of slotted opto transducer.
8.	To study the construction and characteristics of a moving coil loudspeaker.
9.	Microprocessor 8085.
10.	To determine the characteristics of the differential transformer as position transducer.
11.	To understand the operation of a closed loop ON-OFF control system and also to understand the effects of hysteresis on the control.
12.	To study various parts of a robotics development kit.
13.	To study the working of the five-axis robotic arm.

Course Code: ME 3603	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	Automobile Engineering (ME 3603)		
Course Objectives	• To impart knowledge on vehicle structure • To provide an insight into steering, suspension, braking and transmission systems • To familiarize oneself with the ergonomic, comfort, and safety systems • To acquire knowledge on automotive vehicle testing and standards		
Course Outcomes			**Cognitive Levels**
CO1	To enable students to understand the functions of various components/subassemblies of automobiles.		Knowledge/Comprehension (Level I/Level-II)
CO2	To apply engineering design principles to the components of Automobiles		Application/Analysis (Level-III/Level-IV)

CO3	Understand recent trends in alternative fuels and safety systems	Knowledge/Comprehension (Level I/Level-II)
CO4	Recommend a suitable chassis layout and body construction for different vehicles	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Demonstrate the working of transmission and steering systems	Application/Evaluation (Level-III/Level-VI)
CO6	Evaluate the functionality of suspension and braking systems	Synthesis/Evaluation (Level-V/Level-VI)
CO7	Assess the significance of comfort and safety systems in a vehicle	Application/Analysis (Level-III/Level-IV)

Semester	**VI**		**Even**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Automobile Mechanics
	Author	N. K. Giri
	Publisher	Khanna Publishers, 2014.
	Edition	5th Edition
2.	Title	Automobile Engineering
	Author	Rajput R K
	Publisher	Laxmi Publications, 2008
	Edition	1st Edition
3.	Title	Automobile Engineering
	Author	Dr. Kirpal Singh
	Publisher	Standard Publishers, New Delhi, 2020
	Edition	13th Edition, Vol. 1 & 2
4.	Title	Vehicle Testing And Homologation
	Author	K.V. Fadadu, B.H.Kadiya
	Publisher	Books India Publications, 2016
	Edition	1st Edition
5.	Title	Automobile Engineering
	Author	R. B. Gupta,
	Publisher	Satya Publishers, 2016
	Edition	7th Edtion
6.	Title	Automobile Engineering
	Author	GBS Narang
	Publisher	Khanna Publishers, 1995
	Edition	5th Edition
Reference Books		
1.	Title	Bosch Automotive Handbook
	Author	Robert Bosch
	Publisher	Wiley publications, 2018

	Edition	10th Edition	
2.	Title	Automotive Chassis Systems	
	Author	James D. Halderman	
	Publisher	Pearson Publishers, US, 2016.	
	Edition	7th Edition	
3.	Title	Automotive Technology - A Systems Approach,	
	Author	Jack Erjavec, Martin Restoule, Stephen Leroux, Rob D. Thompson,	
	Publisher	Nelson Education Limited, Canada, 2015.	
	Edition	3rd Edition	
4.	Title	Modern Automotive Technology	
	Author	James E Duffy	
	Publisher	Goodheart - Willcox, US, 2013	
	Edition	8th Edition	
Course Contents	**UNIT I: 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.		**8**
	UNIT II: Engine induction and Exhaust Systems: Requirements and considerations. Manifold flowpaths and tuning. Introduction to exhaust gas extraction. Turbocharging, types, variable geometry turbocharger.		**5**
	UNIT III: 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 & Advances in Automobile engineering.		**5**
	UNIT IV: 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.		**6**
	UNIT V: 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.		**6**
	UNIT VI: 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.		**6**

Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

AUTOMOBILE ENGINEERING LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
14.	Case study of chassis and body
15.	Dismantle and assemble a gearbox
16.	Study of transfer case, propeller shaft, slip joint and universal joint
17.	Dismantle and assemble a steering gearbox
18.	Dismantle and assemble a differential and rear axle
19.	Dismantle and assemble a clutch
20.	Determination of camber, caster, toe-in/toe-out
21.	Study on the hydraulic brake system
22.	Study on the air brake system
23.	Case study on advanced technologies (ABS, EBD, TCS, ESP)
24.	Performance test on two-wheeler chassis dynamometer
25.	Performance test on four-wheeler chassis dynamometer
26.	Case study of chassis and body
27.	Dismantle and assemble a gearbox

Course Code: ME 3604	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Refrigeration and Air Conditioning (ME 3604)		
Course Objectives	Upon completion of this course, students will be able to: • **Understand Thermodynamic Fundamentals –** Apply the laws of thermodynamics, heat/work principles, and Carnot cycles to refrigeration and air conditioning systems. • **Evaluate Air Refrigeration Systems –** Identify the limitations of reversed Carnot cycles and assess the Bell-Coleman cycle, compare different air cycle refrigeration systems and their applications in aircraft refrigeration.		

	• **Analyze Vapour Compression Refrigeration Systems (VCRS) –** Examine modifications in reversed Carnot cycles and standard VCRS, including superheating, subcooling, and throttling losses, evaluate multi-stage, multi-evaporator, and cascade systems, along with refrigerant properties. • **Understand Vapour Absorption Refrigeration Systems –** Describe the working principles and components of absorption systems, compare aqua-ammonia and lithium bromide-water systems with vapour compression systems. • **Identify and Assess Refrigeration System Components –** Assess the function and performance of compressors, condensers, evaporators, and expansion devices in refrigeration systems. • **Design Air-Conditioning Systems –** Use psychrometric principles to analyze air-conditioning processes, calculate cooling loads, and design systems for comfort and efficiency.

Course Outcomes		**Cognitive Levels**
CO1	Explain fundamental thermodynamic concepts, refrigeration principles, and the working of heat engines, refrigerators, and heat pumps.	Comprehension (Level-II)
CO2	Analyze the limitations of reversed Carnot cycles and evaluate the performance of Bell-Coleman and air cycle refrigeration systems.	Analysis (Level-IV)
CO3	Examine vapour compression refrigeration systems (VCRS), including modifications, superheating, subcooling, and multi-stage configurations.	Analysis (Level-IV)
CO4	Compare vapour absorption refrigeration systems (VARS) with vapour compression systems and assess working principles of aqua-ammonia and LiBr-water systems.	Analysis/Synthesis (Level-IV/Level-V)
CO5	Classify and assess the performance of refrigeration system components such as compressors, condensers, evaporators, and expansion devices.	Application/Analysis (Level-III/Level-IV)
CO6	Interpret psychrometric charts, analyze air-conditioning processes, and perform cooling load calculations for comfort and industrial applications.	Application/Synthesis (Level-III/Level-V)

Semester	**VI**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	ME 2302 - Engineering Thermodynamics				
Text Books					
1.	Title	Refrigeration and Air-Conditioning			

	Author	C. P. Arora	
	Publisher	McGraw Hill	
	Edition	4th	
2.	Title	Principles of Refrigeration	
	Author	R. J. Dossat	
	Publisher	Pearson Education India	
	Edition	4th	
Reference Books			
1.	Title	Refrigeration and Air Conditioning	
	Author	W.F. Stoecker and J. W. Jones	
	Publisher	McGraw Hill	
	Edition	2nd	
2.	Title	Refrigeration and Air Conditioning	
	Author	M. Prasad	
	Publisher	New Age International Publishers	
	Edition	3rd	
Course Contents	**UNIT I - 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.		**03**
	UNIT II - 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.		**05**
	UNIT III - 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.		**09**
	UNIT IV - 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.		**03**
	UNIT V - REFRIGERATION SYSTEM COMPONENTS Classifications of compressors, performance characteristics of reciprocating		**05**

	compressors, classifications of evaporators & condensers and their characteristics, expansion devices – capillary tube and thermostatic expansion valves.	
	UNIT VI - 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.	**11**
Course Assessment	Total Marks = 100 Continuous Evaluation = 20% Mid Semester = 30% End Semester = 50%	

Course Code: ME 4701	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory Course		
Course Title & Code	Industrial Engineering and Management (ME 4701)		
Course Objectives	• To focus on optimizing complex systems and processes in various industries. • To combine engineering principles with business management techniques to improve overall productivity and performance. • To analyze and evaluate various factors and manage business/industrial systems involving people, materials, methods, and machines.		

Course Outcomes		**Cognitive Levels**
CO1	Describe the core features of the management and productivity management function at the managerial and strategic levels, specifically the relationships between people, process, technology, productivity, and quality, and how it contributes to the competitiveness of firms.	Analysis/Comprehension (Level IV/Level-II)
CO2	Understand industrial engineering concepts to optimize industrial resources	Knowledge/Analysis (Level-I/Level-IV)
CO3	Use plant layout concepts to develop and expand the industrial layouts.	Application/Analysis (Level-III/Level-IV)
CO4	Apply forecasting and materials management for the smooth functioning of the industry on the shop floors	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Analyse the quality of products and services in an industrial scenario with the concept of quality management.	Analysis/Evaluation (Level IV/Level-II)

Semester	**VII**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching**

Syllabus of Departmental Core Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

					Hours
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Industrial Engineering and Production Management			
	Author	Martland T Telsang			
	Publisher	S. Chand & Co Ltd, 2006			
	Edition	1st Edition			
2.	Title	Human Factors in Engineering Design			
	Author	E. J. McCormick			
	Publisher	Tata McGraw Hill, 1993			
	Edition	6th Edition			
Reference Books					
1.	Title	Modern Production Management			
	Author	Elwood S. Buffo Rakesh K. Sarin			
	Publisher	John Wiley & Sons, 2007			
	Edition	8th Edition			
2.	Title	Production and Operations Management			
	Author	Jocobs, C.A.			
	Publisher	Tata McGraw Hill, 1998			
	Edition	8th Edition			
Course Contents	**UNIT I**: **Industrial Engineering:** Meaning, Definition, Objective, Need, Scope and Evolution. Definition, role, and scope of industrial engineering, industrial engineering approach and techniques, principles of organization, elements of organization, types of organization. **Productivity:** Definition of productivity Measurement of productivity, factors affecting the productivity, productivity improvement programs, wages and incentives (simple numerical problems). **Plant layout,** site selection, types of plant layout, factors affecting layout, plant building, flexibility and expansion.				**10**
	UNIT II: Work study: Method study, method study techniques, work measurement techniques, time study, observed time, basic time, normal time, allowances, standard time. Materials Management: Introduction, inventory, inventory costs, inventory cost relationship, inventory control models, ABC analysis MRP, elements of MRP.				**8**

	UNIT III: **Introduction and functions of Management**: Concept, features, natures and importance of management, principles of scientific management, effective management. Concept of planning and its types, objective Concept of organizing and forms of organization structure. Concept of staffing recruitment, selection, training and development. Motivation theory and applications, leadership. Controlling and its techniques. **Quality Management:** Quality, dimensions of quality, quality control, basic QC tools, introduction to statistical quality control, quality assurance six-sigma introduction.	**8**
	UNIT IV: **Sales Forecasting Introduction**, objectives of sales forecasting, types of forecasting methods and numerical problems, **Basics of project management,** network analysis, Critical path method, Program evaluation and review technique, Comparison between CPM and PERT Advancement in Industrial Management: Industry 4.0, lean and Agile Project Management, sustainable industrial practices, case studies pertains to advanced industrial practices.	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4702	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	Y	N
Type of Course	Theory and Practical		
Course Title & Code	CAD/CAM (ME 4702)		
Course Objectives	• To understand the configuration and peripherals required for CAD systems, and develop foundational knowledge in computer graphics, including 2D and 3D transformations, projections, and modeling techniques such as wireframe, surface, and solid modeling. • To gain the knowledge in using CAD and analysis software tools like AutoCAD, PRO ENGINEER, and ANSYS for drafting, simulation, and product development applications. • To learn the fundamentals of Computer Aided Manufacturing (CAM) including numerical control (NC) machines, tooling, ISO G & M codes, and NC part programming using APT and other methods. • To explore modern manufacturing systems, including Computer Aided Process Planning (CAPP) and Flexible Manufacturing Systems (FMS), for efficient and automated production processes.		

Course Outcomes		**Cognitive Levels**
CO1	Understand and analyze the hardware configuration and peripherals required for CAD applications and explain the	Analysis/Comprehension (Level IV/Level-II)

	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.	Knowledge/Analysis (Level-I/Level-IV)
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.	Application/Analysis (Level-III/Level-IV)
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.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	2	4	36
Prerequisite course codes with course names	NA				

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

Reference Books		
1.	Title	CAD / CAM Principles and Applications
	Author	Rao, P.N.
	Publisher	McGraw Hill Publishers
	Edition	2010

Course Contents	**UNIT I**: **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.	**8**
	UNIT II: 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	**10**

	application.	
	UNIT III: 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.	**10**
	UNIT IV: Introduction to Computer Aided Process Planning: Introduction to Flexible Manufacturing Systems.	**8**

Course Assessment	Total Marks =100 Theory (75 Marks) Evaluation will be done for 100 marks and 75% of the marks secured will be considered.	Continuous Evaluation 20% Mid Semester 30% End Semester 50%
	Practical (25 Marks) Evaluation will be done for 50 marks and 50% of the marks secured will be considered.	Continuous Evaluation 20% Laboratory Examination 50% Viva Voce 30%

CAD/CAM LAB

LIST OF EXPERIMENTS

Sl. No.	Experiments
1.	Drafting practice using drafting package for drawing option.
2.	Drafting practice using drafting package for modify option.
3.	Drafting practice using drafting package for a dimensional approach.
4.	Programming practice for a given problem.
5.	Programming practice for graphic application.
6.	Practice for data exchange from draft package.
7.	Drafting of design component.
8.	Demonstration of 3D modeling using CAD packages.
9.	Demonstration of stress analysis using FEA package.
10.	Manual part programming for CNC turning and milling centres.
11.	Use of simulation software for turning and milling CNC machines.

Syllabus of Departmental Elective I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 3571	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Al and ML in Mechanical Engineering (ME 3571)		
Course Objectives	• To impart knowledge of AI and ML • To be able to formulate and consider AI and ML in engineering applications		

Course Outcomes		**Cognitive Levels**
CO1	To get familiarize with the basics of statistics in data analysis	Comprehension /Analysis (Level II/Level-III)
CO2	Understanding the various machine learning algorithms and applications	Knowledge/Application/Analysis (Level-I/ Level-III/Level-IV)
CO3	To introduce to neural networks and the various deep learning algorithms	Knowledge/Application/Analysis (Level-I/Level-III/Level-IV)
CO4	To introduce python and its applications in AI and ML	Application/Evaluation (Level-III/Level-VI)
CO5	To understand the application of AI and ML in the respective engineering streams	Knowledge/Analysis/Evaluation (Level-I/Level-IV/Level-VI)

Semester	**V**	**ODD**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Essential Math for Data Science
	Author	Thomas Nield
	Publisher	O' Reilly Media
	Edition	1st Edition

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

Course Contents		
	UNIT I: 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	**6**
	UNIT II: Machine Learning Algorithms	**10**

	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	
	UNIT III: 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	**8**
	UNIT IV: 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	**6**
	UNIT V: Applications SHM Paradigm, feature extraction, feature importance, correlation, and eigenvalue analyses, feature augmentation, performance and validation of ML/DL models in mechanical engineering applications	**6**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3572	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Introduction to Two Phase Flow (ME 3572)		
Course Objectives	• To familiarize with the theory of two-phase flow and equations involving in it. • To formulate and analyze problems related to homogeneous, separated, and drift-flux models. • To classify different types of fluid systems and fluid flows.		

Course Outcomes		**Cognitive Levels**
CO1	Understand the concept of two-phase flow, its different types (e.g., gas-liquid, liquid-liquid, solid-liquid), and the relevant terminology.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Identify and understand different flow patterns in two-phase flow.	Comprehension /Analysis (Level-II/Level-IV)
CO3	Learn different correlations for pressure drop and void fractions.	Knowledge/Synthesis (Level-I/Level-V)
CO4	Study various flow regimes of boiling.	Application/Analysis (Level-III/Level-IV)

Syllabus of Departmental Elective I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Semester		**V**			**ODD**		
Contact Hours		**Lecture**	**Tutorial**	**Practical**		**Credits**	**Total Teaching Hours**
		3	0	0		3	36
Prerequisite course codes with course names		Fluid Mechanics (ME 2304)					
Text Books							
1.	Title	Two-Phase Flow: Theory and Applications					
	Author	C. Kleinstreuer					
	Publisher	Taylor & Francis, 2003.					
	Edition	1st Edition					
Reference Books							
1.	Title	Convective Boiling and Condensation					
	Author	J.G. Collier and J.R. Thome					
	Publisher	Oxford University Press, 1996					
	Edition	3rd Edition					
2.	Title	One-Dimensional Two-Phase Flow,					
	Author	G.B. Wallis					
	Publisher	McGraw-Hill, 1969					
	Edition	1st Edition					
3.	Title	Boiling, Condensation and Gas-Liquid Flow.					
	Author	P B Whalley					
	Publisher	Oxford University Press, 1987					
	Edition	1st Edition					
4.	Title	L Boiling Heat Transfer and Two-Phase Flow					
	Author	.S. Tong and Y.S. Tang					
	Publisher	Taylor and Francis, 1997					
	Edition	2nd Edition					
5.	Title	Thermo-Fluid Dynamics of Two-Phase Flow,					
	Author	M. Ishii and T. Hibiki					
	Publisher	Springer, 2006.					
	Edition	1st Edition					
Course Contents	**UNIT I**: Formulation and Solution to Phase Change Problem, Two Phase Flow Fundamentals.						**8**
	UNIT II: Review of one-dimensional conservation equations in single-phase flows.						**6**
	UNIT II: Governing equations for homogeneous, separated and drift-flux model; Flow pattern maps for horizontal and vertical systems.						**12**
	UNIT III: Simplified treatment of stratified, bubbly, slug and annular flows.						**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20%						

	Mid Semester 30% End Semester 50%

Course Code: ME 3573	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Introduction to Turbulent Flow (ME 3573)		
Course Objectives	• To provide a general introduction to the physics and mathematical description of turbulence • To introduce the methods of analysis used in turbulence study • To understand the principles of turbulence simulation and modeling. that it is assigned		

Course Outcomes		**Cognitive Levels**
CO1	Identify and understand various turbulence models and their limitations.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Understand the fundamental concepts of fluid mechanics and turbulence.	Analysis/Synthesis (Level-IV/Level-V)
CO3	Apply statistical methods to analyze turbulent flows.	Application/Analysis (Level-III/Level-IV)
CO4	Predict and simulate turbulent flows using numerical methods	Analysis/Evaluation (Level-IV/Level-VI)

Semester	**V**	**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Fluid Mechanics (ME 2304)				

Text Books		
1.	Title	Fundamentals of Heat and Mass Transfer
	Author	F.P Incropera, D.P Dewitt
	Publisher	John Wiley,2002
	Edition	5th Edition
2	Title	Heat Transfer,
	Author	J.P Holman
	Publisher	Tata McGraw-Hill, 2004.
	Edition	9th Edition
Reference Books		
1.	Title	Turbulent Flows
	Author	Stephen B. Pope
	Publisher	Cambridge University Press, 2000

	Edition	1st Edition	
2.	Title	Modern Compressible Flow,	
	Author	J. D. Anderson	
	Publisher	Mc Graw Hill, 1989	
	Edition	1st Edition	
3.	Title	The Dynamics and Thermodynamics of Compressible Flow	
	Author	P. A. Davidson	
	Publisher	The Ronald Press Co., 1954	
	Edition	1st Edition	
4.	Title	Turbulent Flows: Fundamentals, Experiments and Modeling	
	Author	G. Biswas and V. Eswaran	
	Publisher	Narosa Publishing House, 2002	
	Edition	1st Edition	
5.	Title	Turbulent Flow,	
	Author	R. J. Garde	
	Publisher	New Age International Publishers, 2000.	
	Edition	1st Edition	
6.	Title	Homogeneous Turbulence Dynamics,	
	Author	Pierre Sagaut and Claude Cambon,	
	Publisher	Cambridge University Press, 2008.	
	Edition	1st Edition	
7.	Title	A First Course in Turbulence,	
	Author	H. Tennekes and J. L. Lumely	
	Publisher	The MIT Press, 1972.	
	Edition	1st Edition	
Course Contents	**UNIT I**: Introduction: Transition from laminar to turbulence, nature of turbulence and irregularity, types of turbulent flows, three-dimensional motions.		**14**
	UNIT II: Statistical Description of Turbulence, Kolmogorov hypothesis, turbulence spectra.		**12**
	UNIT III: Introduction to turbulence modelling and experimental method.		**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30%		

	End Semester 50%

Course Code: ME 3574	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Advanced Solid Mechanics (ME 3574)		
Course Objectives	• To analyze the transformation of stresses and strains in 3D elasticity. • To study engineering properties of materials, force-deformation, and stress-strain relationships. • To study the solutions of some of the classical boundary value problems		

Course Outcomes		**Cognitive Levels**
CO1	To get familiar with the mathematical preliminaries	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand the concept of stress and equilibrium	Knowledge/Analysis (Level-I/Level-IV)
CO3	To understand the measure of deformation and the compatibility conditions	Application/Analysis (Level-III/Level-IV)
CO4	To understand the elastic constitutive relations	Synthesis/Evaluation (Level-V/Level-VI)
CO5	To solve and understand the solutions of boundary value problems in classical elasticity	Application/Analysis (Level-III/Level-IV)

Semester	**V**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Mechanics of Deformable Bodies (ME 2303)				

Text Books		
1.	Title	Advanced mechanics of solids
	Author	L. S. Srinath
	Publisher	McGraw Hill Education
	Edition	3rd Edition
2.	Title	Theory of Elasticity
	Author	T. G. Sitharam, L. Govindaraju
	Publisher	Springer Singapore
	Edition	1st Edition
Reference Books		
1.	Title	Theory of Elasticity

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	Author	S. P. Timoshenko and J. N. Goodier	
	Publisher	McGraw Hill Education	
	Edition	3rd Edition	
Course Contents	**UNIT I**: **Introduction** Introduction, Conceptual foundations, Mathematical preliminaries		**4**
	UNIT II: Stress and Strain Stress field (Traction, Cauchy's principle, Stress tensor, Equilibrium equations, Principal stresses)		**9**
	UNIT III: Strain Kinematics of deformable bodies (Strain tensor, Compatibility)		**8**
	UNIT III: Constitutive relations Constitutive relations (1D and 3D elasticity, thermo-mechanical relations.)		**6**
	UNIT V: 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)		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 3575	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	**Y**
Type of Course	Theory Course		
Course Title & Code	Non-Destructive Testing (ME 3575)		
Course Objectives	• To understand the importance of identifying defects • To gain insights on various Non-Destructive Techniques (NDT) available • To have capabilities and limitations on the various non-destructive techniques		

Course Outcomes		**Cognitive Levels**
CO1	Students will be able to understand the fundamental aspects and applications of non-destructive testing	Analysis/Comprehension (Level IV/Level-II)
CO2	Students will be able to understand the ultrasonic based techniques in NDT	Knowledge/Analysis (Level-I/Level-IV)
CO3	Students will be able to understand thermography techniques in NDT	Application/Analysis (Level-III/Level-IV)
CO4	Students will be able to understand the radiography and its application in defect detections	Synthesis/Evaluation (Level-V/Level-VI)

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CO5	Students will be able to understand the eddy current based techniques in identifying defects	Knowledge/Analysis (Level-I/Level-IV)
CO6	Students will be able to understand the different acoustic emission and magnetic particle based inspection techniques in identifying defects	Knowledge/Analysis (Level-I/Level-IV)

Semester	**V**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Practical Non-Destructive Testing
	Author	Baldev Raj, M. Thavasimuthu, T. Jayakumar
	Publisher	Narosa Publishing House
	Edition	3rd Edition

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

Course Contents	**UNIT I: Introduction to NDT** Liquid penetrant test: Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples	**6**
	UNIT II: 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.	**6**
	UNIT III: Thermography Basic principles, Detectors and equipment, techniques, applications	**5**
	UNIT IV: Radiography Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples	**5**

	UNIT V: Eddy current test Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations	**6**
	UNIT VI: 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.	**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3576	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Elements of Plastic Technology (ME 3576)		
Course Objectives	To understand the mechanism of polymerization, techniques of polymerization and the significance of different molecular weight averages. • To provide in depth knowledge about different kinds of plastic materials based on their structure and properties • To make the student familiar about the properties and end applications of different plastics materials To create the knowledge about the different testing techniques and its basic concepts for evaluating the chemical, mechanical, electrical, optical, thermal, and permanence properties of plastic materials. • To enable the students to identify and compare the properties of different plastics materials. • To enable the students to learn about the property of the plastic material for several applications.		

Course Outcomes		**Cognitive Levels**
CO1	Analyze effect of processing variables on the product quality in injection, compression molding and extrusion process.	Analysis/Comprehension (Level IV/Level-II)
CO2	Evaluate effect of various design parameters on plastic processing.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Select suitable material for moulds used in the plastic industry.	Application/Analysis (Level-III/Level-IV)
CO4	Ability to test the plastics materials for its chemical, mechanical, electrical, optical, thermal, and permanence properties as per the standard.	Synthesis/Evaluation (Level-V/Level-VI)

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CO5	Ability to identify the plastic materials by reverse engineering for some specified applications with the knowledge of testing.				Application/Analysis (Level-III/Level-IV)
Semester	**V**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Shreve's Chemical Process Industries			
	Author	Randolph Norris Shreve and George T. Austin			
	Publisher	McGraw Hill Education, 2017			
	Edition	5th Edition			
2.	Title	Plastic Materials			
	Author	J. A. Brydson			
	Publisher	ButterWorth Heinemann, 1999			
	Edition	7th Edition			
3.	Title	Testing & Recycling of Plastics			
	Author	Roger P. Brown			
	Publisher	CBS Publishers and distributors, 2004			
	Edition	2nd Edition			
Reference Books					
1.	Title	Hand Book of Plastics Test Methods			
	Author	Brown; Paul F (Ed)			
	Publisher	Longman Scientific and Technical, Harlow			
	Edition	1st Edition, 1988			
2.	Title	Electrical Properties of Polymers,			
	Author	Blythe, A. R.			
	Publisher	Cambridge University Press, 2005			
	Edition	2nd Edition			
Course Contents	**UNIT I**: **Manufacturing Technologies for Thermoplastics-** Unit Operations in Plastic Materials Manufacture; Manufacture of Commodity plastic materials.				**4**
	UNIT II: Plastics Processing Techniques: Injection Molding: process, Extrusion: process, Blow Molding: process, Thermoforming: process Compression Molding: process.				**10**
	UNIT III: Manufacture of Engineering Thermoplastic Materials: Manufacture with plant layout for Nylon-6, / 66 resins, PEEK, PPS, PC,				**10**

	Acetal Copolymers, PET, PTFE, etc. Applications, Advantages, and Disadvantages of each resin.	
	UNIT IV: **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.	**12**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3577	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	**Y**
Type of Course	Theory Course		
Course Title & Code	Acoustics (ME 3577)		
Course Objectives	• To understand the phenomenon of sound waves and its applications in engineering • To understand the mathematical modeling aspect of acoustic waves		

Course Outcomes		**Cognitive Levels**
CO1	An understanding of the sound waves	Knowledge /Comprehension (Level I/Level-II)
CO2	To be able to analyze the mathematical modeling aspects of sound waves	Knowledge/Analysis (Level-I/Level-III)
CO3	Basic understanding of the terminologies in acoustics	Application/Analysis (Level-III/Level-IV)
CO4	To understand the importance of impedance in sound wave propagation	Synthesis/Evaluation (Level-V/Level-VI)
CO5	To understand sound wave propagation in waveguides	Knowledge/Analysis (Level-I/Level-IV)

Semester	**VIII**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

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Prerequisite course codes with course names	NA		
Text Books			
1.	Title	Fundamentals of Acoustics	
	Author	Lawrence E. Kinsler, Austin R. Frey, Alan B. Coppens, James V. Sanders	
	Publisher	John Wiley and Sons	
	Edition	4th Edition	
Reference Books			
1.	Title	Theoretical Acoustics	
	Author	Philip M. Morse and Uno Ingard	
	Publisher	Princeton University Press	
	Edition	1st Edition, 1986	
2.	Title	Fundamentals of Physical Acoustics	
	Author	David T. Blackstock	
	Publisher	John Wiley	
	Edition	1st Edition, 2000	
Course Contents	**UNIT I: Introduction to wave phenomenon** Introduction, Terminology, Forward and backward propagating pulse, Sound or wave speed		**4**
	UNIT II: 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		**10**
	UNIT III: 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		**6**
	UNIT IV: 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		**8**
	UNIT V: 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,		**8**

	evanescent modes, Gradually varying area ducts: Webster's horn equation, Ducts with compliant walls	
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3578	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Tribology (ME 3578)		
Course Objectives	• To impart knowledge on friction, wear, and lubrication. • To acquire knowledge of surface coatings and measurements. • To study the causes and effects of friction and wear in engineering applications. • To explore lubrication techniques and their role in reducing friction and wear. • To introduce methods for enhancing material performance through surface treatments and coatings.		

Course Outcomes		**Cognitive Levels**
CO1	Grasp the basics of tribology and associated parameters.	Knowledge/Comprehension (Level-I/Level-II)
CO2	Utilize tribological principles to evaluate the performance and guide the design of components subjected to relative motion	Application/Evaluation (Level-III/Level-VI)
CO3	Analyse and evaluate the characteristics of surfaces to forecast their tribological behavior.	Analysis/Evaluation (Level-IV/Level-VI)
CO4	Recognise the lubrication regime for various mechanical applications.	Comprehension/Synthesis (Level-II/Level-V)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Engineering Tribology			
	Author	Stachowaik, G.W. and Batchelor, A.W.			
	Publisher	Elsevier, 2010			

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	Edition	3rd Edition	
2.	Title	Introduction to Tribology	
	Author	B. Bhushan	
	Publisher	John Wiley & Sons, Inc., New York, 2013	
	Edition	2nd Edition	
Reference Books			
1.	Title	Basic Lubrication Theory	
	Author	A Cameron and C.M. Mc Ettles	
	Publisher	1987, Wiley Eastern Ltd., New Delhi.	
	Edition		
Course Contents	**UNIT I**: **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.		**8**
	UNIT II: 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.		**10**
	UNIT III: 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.		**10**
	UNIT IV: 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.		**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

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Course Code: ME 3671	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Theory of Microfluidics (ME 3671)		
Course Objectives	• To acquire elementary knowledge of Microfluidics and Microfabrication. • To explain the features and dynamics of Microscale fluid flows. • To discuss the various safety procedures that needs to be followed inside a cleanroom • To design a microsystem based on its intended applications and the tools available for its fabrication.		

Course Outcomes		**Cognitive Levels**
CO1	To gain an understanding of the fundamental theories of microfluidics.	Analysis/Comprehension (Level II/Level-III)
CO2	To be able to describe the various microfabrication techniques.	Knowledge/Analysis (Level-III/Level-II)
CO3	To be able to analyse and solve problems on fluid flow at microscale level using appropriate mathematical tools.	Application/Analysis (Level-IV/Level-V)
CO4	To be able to identify and evaluate the diverse applications of microfluidics.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VI**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	Fluid Mechanics (ME 2304)

Text Books		
1.	Title	Introduction to microfluidics
	Author	Paul Tabeling
	Publisher	Oxford University Press
	Edition	2nd Edition
Reference Books		
1.	Title	Microfluidics-Enabled Soft Manufacture
	Author	Pingan Zhu , Liqiu Wang
	Publisher	Springer International Publishing
	Edition	1st Edition
2.	Title	Microfluidics and Lab-on-a-chip

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	Author	Andreas Manz, Pavel Neužil, Jonathan S O'Connor, Giuseppina Simone	
	Publisher	Royal Society of Chemistry	
	Edition	1st Edition	
Course Contents	**UNIT I**: 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).		**9**
	UNIT II: Microfluidic Fluid Flow: Governing Equations of Microfluidics (Navier-Stokes equations for microscale flows, Boundary layer theory in microchannels), ElectrokineticPhenomena (Electroosmosis, electrophoresis, and Dielectrophoresis), Capillary Effects (Surface tension, wetting, and capillary action in microchannels).		**9**
	UNIT III: Microfluidic Components and Systems: Microvalves, Micropumps, Micromixers, Lab-on-a-chip, Fabrication Methods (Photolithography, soft lithography, and 3D printing)		**9**
	UNIT IV: Applications: Biomedical Applications, Chemical Analysis, Environmental Applications, Future Trends and Innovations		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 3672	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Material Handling (ME 3672)		
Course Objectives	• To provide students with a comprehensive understanding of the fundamental principles, functions, and classification of material handling systems used in manufacturing and logistics industries. • To develop the ability to analyze different materials handling needs and apply engineering principles to design efficient and cost-effective material handling systems. • To familiarize students with modern automated material handling technologies and emphasize the importance of safety standards and ergonomics in system design and operation.		
Course Outcomes			**Cognitive Levels**

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CO1	Understand the procedures for systematic integration of organization.	Analysis/Comprehension (Level IV/Level-II)
CO2	Learn various techniques and tools of layout planning.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Get knowledge of various industrial layouts.	Application/Analysis (Level-III/Level-IV)
CO4	Understand the material handling systems.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Learn the concept of industrial building and industrial utilities.	Application/Analysis (Level-III/Level-IV)

Semester	**VI**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Plant layout and material handling.
	Author	S. C. Sharma.
	Publisher	Khanna publishers, 2015
	Edition	3rd Edition
2.	Title	Plant Layout and Material Handling.
	Author	James M. Apple.
	Publisher	John Wiley & Sons, 1977
	Edition	3rd Edition
Reference Books		
1.	Title	Materials Handling (Principles & Practice)
	Author	T.H. Allegri
	Publisher	CBS, 1984
	Edition	1st Edition
2.	Title	Material Handling Systems Design.
	Author	James M. Apple.
	Publisher	John Wiley & Sons, 1977
	Edition	1st Edition

Course Contents	**UNIT I**: 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 Equipments; Design of Mechanical Handling Equipments; Design of Hoists Design of Cranes	**8**

	UNIT II: 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.	**10**
	UNIT III: 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.	**8**
	UNIT IV: 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.	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3673	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Introduction to Combustion Engineering (ME 3673)		
Course Objectives	• To understand the fundamentals of combustion, thermochemistry, and flame behavior. • To learn the principles of mass transfer and chemical kinetics in reacting systems. • To explore important chemical reaction mechanisms relevant to fuel combustion. • To apply conservation laws to analyze laminar premixed and diffusion flames. • To evaluate pollutant formation and emission characteristics in combustion systems.		

Course Outcomes		**Cognitive Levels**
CO1	Explain combustion fundamentals, flame types, and thermochemical principles.	Analysis/Comprehension (Level IV/Level-II)

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CO2	Apply mass transfer and chemical kinetics concepts to combustion processes.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Analyze chemical mechanisms and ideal reacting systems.	Application/Analysis (Level-III/Level-IV)
CO4	Formulate conservation equations for reacting flows and describe laminar premixed flames.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Describe laminar diffusion flames and evaluate combustion emissions.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VI**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Applied Thermodynamics (ME 2401) Heat and Mass Transfer (ME3501)				

Text Books		
1.	Title	An Introduction to Combustion
	Author	S. R. Turns
	Publisher	McGraw Hill
	Edition	2nd Edition
2.	Title	Combustion
	Author	J. Warnatz, U. Mass and R. W. Dibble
	Publisher	Springer
	Edition	3rd Edition
Reference Books		
1.	Title	Combustion Theory
	Author	F. A Wiiliams
	Publisher	Addison Wesley Publishing Company
	Edition	2nd Edition

Course Contents	**Unit 1:** 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.	**8**
	Unit 2: 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.	**8**
	Unit 3: 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	**8**

	mass reactor, constant-volume fixed mass reactor, well-stirred reactor, plug-flow reactor.	
	Unit 4: 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.	**8**
	Unit 5: 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.	**4**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3674	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Energy Conservation and Waste Heat Recovery (ME 3674)		
Course Objectives	• Explore energy use across industries and master smart strategies like cogeneration and combined cycles. • Evaluate system efficiency using exergy analysis and learn how to tap into industrial waste heat. • Dive into innovative heat recovery tools-heat pipes, thermoelectrics, and HVAC integrations. • Understand modern energy storage solutions and their economic impact on sustainable systems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand various energy resources, their industrial applications, and the importance of energy conservation, audits, and cogeneration systems.	Analysis/Comprehension (Level IV/Level-II)
CO2	Evaluate energy systems using exergy and availability analysis, and identify suitable waste heat recovery methods for improving thermal efficiency.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Analyze and compare advanced heat recovery systems including heat pipes, thermoelectric systems, and heat pumps for diverse industrial and HVAC applications.	Application/Analysis (Level-III/Level-IV)

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CO4	Identify and assess suitable energy storage techniques and interpret energy economics for sustainable energy management in engineering systems.				Synthesis/Evaluation (Level-V/Level-VI)
Semester	**VI**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Fluid Mechanics (ME 2304), Heat and Mass Transfer (ME 3501)				
Text Books					
1.	Title	Combined Heat and Power			
	Author	J. H. Harlock			
	Publisher	Pergaman Press			
	Edition	1st Edition			
2.	Title	Thermal Energy Recovery			
	Author	T. L. Boyen			
	Publisher	Wiley Eastern.			
	Edition	1st Edition			
Reference Books					
1.	Title	Energy Efficiency			
	Author	F. Kreith and R. E. West			
	Publisher	CRC Press			
	Edition	2nd Edition			
Course Contents	**UNIT I:** 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.				**10**
	UNIT II: 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.				**8**
	UNIT III: 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.				**9**
	UNIT IV: 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				**9**

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Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: ME 3675	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Composite Materials (ME 3675)		
Course Objectives	• Provide students a basic understanding and uses of composite materials; develop skill to understand different composites manufacturing methods. • To enable the students to find physical and mechanical properties of composites using micromechanics and experimental methods. • Illuminate the knowledge and skills to design the composite laminate subjected to different in-plane loading conditions.		

Course Outcomes		**Cognitive Levels**
CO1	Apply knowledge of Metals, Composites, their science and engineering involved, and different fabrication methods available for the fabrication of composite materials.	Knowledge/Comprehension (Level I/Level-II)
CO2	Analysis the mechanical and tribological behaviour of the composite materials.	Analysis/Synthesis (Level-IV/Level-V)
CO3	Develop various components made of MMCs, PMCs, CMCs. For different applications.	Application/Analysis (Level-III/Level-IV)

Semester	**VI**	**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

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

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	Edition	2nd Edition	
Reference Books			
1.	Title	Mechanics of Composite Materials	
	Author	Robert Millard Jones	
	Publisher	CRC Press, 1999	
	Edition	1st Edition	
2.	Title	The behavior of structures composed of composite materials, ,	
	Author	Jack R. Vinson, Robert L. Sierakowski	
	Publisher	Springer, Dordrecht, 2006	
	Edition	2nd Edition	
Course Contents	**UNIT I:** Introduction, definition and classification of composite materials, Types of reinforcements, Criteria for the selection of the matrices and reinforcements Its properties, Types of Matrix, Interfaces, Wettability Its importance and application.		**6**
	UNIT II: 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.		**6**
	UNIT III: 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.		**8**
	UNIT IV: 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.		**6**
	UNIT V: 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.		**6**
	UNIT VI: 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]		**4**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

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Course Code: ME 3676	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	**Y**
Type of Course	Theory Course		
Course Title & Code	Introduction to FEM (ME 3676)		
Course Objectives	• To understand the fundamental aspect and applications of finite element method in engineering • To gain insights in FEM modeling of 1D, 2D mechanical systems • To understand the different elements and their formulations employed in FEM		

Course Outcomes		**Cognitive Levels**
CO1	Students will be able to understand the fundamental aspects of finite element method	Analysis/Comprehension (Level IV/Level-II)
CO2	Students will be able to formulate the 1D engineering problems and solve them by hand calculations and FE software.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Students will be able to formulate the 2D engineering problems and solve them by hand calculations and FE software.	Application/Analysis (Level-III/Level-IV)
CO4	Students will be able to understand the integration schemes and different element formulations in FEM.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VI**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books		
1.	Title	Introduction to Finite Elements in Engineering
	Author	Tirupathi R. Chandrupatla, Ashok D. Belegundu
	Publisher	Pearson Education India
	Edition	4th Edition
2.	Title	Finite Element Methods for Engineers
	Author	U.S. Dixit
	Publisher	Cengage Learning, New Delhi and Singapore,
	Edition	1st Edition
Reference Books		
1.	Title	Concept and Applications of Finite Element Analysis

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	Author	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt	
	Publisher	Wiley	
	Edition	4th Edition	
Course Contents	**UNIT I**: **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.		**9**
	UNIT II: **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.		**9**
	UNIT III: **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.		**9**
	UNIT IV: **Numerical Integration and 2-D problems of Elasticity** Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 3677	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	**Y**
Type of Course	Theory Course		
Course Title & Code	Multi-Body Dynamics (ME 3677)		
Course Objectives	• To understand and analyze the dynamics of engineering system		

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	• To formulate and understand the various modeling aspects in multi-body dynamics					
Course Outcomes					**Cognitive Levels**	
CO1	To understand the basic mathematical terminologies				Analysis/Comprehension (Level IV/Level-II)	
CO2	To understand the various frameworks employed in the description of motion				Knowledge/Analysis (Level-I/Level-IV)	
CO3	To be able to formulate and solve the numerical aspect in modeling flexible systems				Application/Analysis (Level-III/Level-IV)	
CO4	To understand and apply multi-body dynamics in various engineering applications				Synthesis/Evaluation (Level-V/Level-VI)	
Semester	**VI**		**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**	
	3	0	0	3	36	
Prerequisite course codes with course names	Engineering Mechanics (ME 1101)					
Text Books						
1.	Title	Dynamics of Multibody Systems				
	Author	Ahmed A. Shabana				
	Publisher	Cambridge University Press				
	Edition	3th Edition, 2005				
2.	Title	Flexible Multibody Dynamics				
	Author	O. A. Bauchau				
	Publisher	Springer Dordrecht				
	Edition	1st Edition, 2010				
Reference Books						
1.	Title	Advanced Dynamics: Rigid Body, Multibody, and Aerospace Applications				
	Author	Reza N. Jazar				
	Publisher	John Wiley and Sons				
	Edition	1st Edition				
Course Contents	**UNIT I** Overview of fundamentals of kinematics and kinetics, Geometric kinematics of rigid multibody systems: Coordinate systems, Rotation, Orientation, Motion and Multibody Kinematics					**9**
	UNIT II 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.					**8**

	UNIT III 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.	**13**
	UNIT IV Application case studies: manipulators, vehicles etc.	**6**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 3678	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Introduction to Power Plant Engineering (ME 3678)		
Course Objectives	• To explain the working principles and layouts of various types of power plants. • To analyze the performance parameters of various power generation systems. • To evaluate the impact of powerplant on the environment and the various economic considerations related to its operation. • To compare between different conventional and non-conventional energy systems for sustainable energy development.		

Course Outcomes		**Cognitive Levels**
CO1	To gain an understanding of the fundamental theories of various types of powerplants	Analysis/Comprehension (Level V/Level-III)
CO2	To describe and analyze the various systems and sub-systems used in steam, gas turbine, and combined cycle power plants.	Knowledge/Analysis (Level-II/Level-V)
CO3	To be able to evaluate the environmental and sustainability considerations in this field.	Application/Analysis (Level-II/Level-V)
CO4	To be able to utilize advanced solidification techniques and their applications.	Synthesis/Evaluation (Level-IV/Level-VI)

Semester	**VI**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**

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	3	0	0	3	36
Prerequisite course codes with course names	Engineering Thermodynamics (ME 2302), Applied Thermodynamics (ME 2401)				

Text Books			
1.	Title	Power Plant Engineering	
	Author	P K Nag	
	Publisher	McGraw Hills	
	Edition	4th Edition	
Reference Books			
1.	Title	Power Plant Engineering	
	Author	Harish C Rai, Shipra Rai	
	Publisher	Wiley	
	Edition	2nd Edition	
2.	Title	Nag's Power Plant Engineering	
	Author	Sudipta De	
	Publisher	McGraw Hills	
	Edition	5th Edition	
Course Contents	**UNIT I**: 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.		**7**
	UNIT II: 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		**10**
	UNIT III: 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.		**11**
	UNIT IV: Non-Conventional Power Generation: Solar thermal and photovoltaic power systems, Wind power generation: types, characteristics, and power curves, Geothermal, tidal, and biomass energy systems.		**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

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Course Code: ME 3679	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Advanced Manufacturing (ME 3679)		
Course Objectives	• To impart knowledge on the advancements of metal forming and metal casting processes. • To give an insight into specialized moulding process, micromachining and finishing processes with potential applications in the medical field. • To facilitate students to understand the advanced machining and hybrid machining processes.		

Course Outcomes		**Cognitive Levels**
CO1	Demonstrate the basics of advanced metal forming and metal casting processes.	Knowledge/Comprehension (Level I/Level-II)
CO2	Discuss various advanced metal casting process with industrial applications.	Analysis/Synthesis (Level-IV/Level-V)
CO3	Select the appropriate machining process based on tool-workpiece interaction and source of energy for the end product.	Application/Analysis (Level-III/Level-IV)
CO4	Recognize the material removal mechanism and process parameters of ultra-precision machining process and micro manufacturing process.	Analysis/Synthesis (Level-IV/Level-V)
CO5	Identify and use various hybrid machining processes for state-of-the-art applications.	Application/Evaluation (Level-III/Level-VI)

Semester	**VI**	**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Manufacturing Processes for Engineering Materials
	Author	Kalpakjian and Schmid
	Publisher	Prentice Hall, 2017
	Edition	5th edition
2.	Title	Fundamentals of Machining Processes (Conventional and Nonconventional Processes)
	Author	Hassan Abdel-Gawad ElHofy

	Publisher	CRC Press, 2018	
	Edition	3rd Edition	
3.	Title	Micro manufacturing processes	
	Author	V. .K. Jain	
	Publisher	CRC Press, 2013	
	Edition	1st Edition	
Reference Books			
1.	Title	Precision Engineering in Manufacturing	
	Author	Murty, R. L.	
	Publisher	New Age International (P) Limited, 1996	
	Edition	1st Edition	
2.	Title	Micro and Nano fabrication	
	Author	Mark J. Jackson	
	Publisher	CRC Press, Taylor & Francis Group, 2010	
	Edition	1st Edition	
3.	Title	Micro manufacturing, Design, and manufacturing of micro products	
	Author	MuammerKoc, TrugelOzel,	
	Publisher	Wiley Publishers, 2011	
	Edition	1st Edition	
Course Contents	**UNIT I: 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.		**6**
	UNIT II: 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.		**4**
	UNIT III: Specialized Molding 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.		**8**
	UNIT IV: 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		**6**

	(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).	
	UNIT V: Ultra-Precision Machining: Diamond turning- mechanism of material removal - process Parameters and Optimization- tool path strategies in surface generation- applications.	**4**
	UNIT VI: 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.	**8**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

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Course Code: ME 4771	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Solar Energy Conversion Technology (ME 4771)		
Course Objectives	• Understand global and Indian energy scenarios and basic thermodynamics. • Learn how solar radiation works and how it's measured. • Explore solar thermal systems like heaters, dryers, and coolers. • Discover how concentrated solar power generates electricity. • Get hands-on knowledge of solar PV systems and latest technologies. • Dive into advanced solar tech like solar photocatalysis and its applications.		

Course Outcomes		**Cognitive Levels**
CO1	Describe the global and Indian energy scenario, classify energy sources, and apply fundamental thermodynamic laws to renewable energy systems.	Analysis/Comprehension (Level IV/Level-II)
CO2	Analyze the geometry of solar radiation, including Earth-Sun relationships, solar angles, and estimation of radiation on various surfaces using Indian data.	Knowledge/Analysis (Level-I/Level-IV)
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.	Application/Analysis (Level-III/Level-IV)
CO4	Evaluate the design and performance of concentrated solar power (CSP) systems and their role in thermal-to-mechanical energy conversion.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Design and assess photovoltaic systems, understand the principles of PV conversion, and analyze system economics for both off-grid and on-grid applications.	Synthesis/Evaluation (Level-V/Level-VI)
CO6	Understand the mechanisms of solar photocatalysis, and explore recent advances and emerging solar energy technologies for environmental and energy applications.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Fluid Mechanics (ME 2304), Heat and Mass Transfer (ME 3501)				

Text Books		
1.	Title	Solar Energy: Principles of Thermal Collection and Storage
	Author	S. P. Sukhatmeand J. K. Nayak

	Publisher	Tata McGraw Hill	
	Edition	3rd Edition	
2.	Title	Handbook of Solar Energy Theory Analysis and Applications	
	Author	Arvind Tiwari, G. N. Tiwari, and Shyam	
	Publisher	Springer	
	Edition	1st Edition	
Reference Books			
1.	Title	Solar Photovoltaics: Fundamentals, Technologies and Applications	
	Author	C. S. Solanki	
	Publisher	Prentice Hall India	
	Edition	2nd Edition	
Course Contents	**UNIT I:** 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.		**4**
	UNIT II: 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.		**8**
	UNIT III: 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.		**8**
	UNIT IV: Concentrated Solar Power: Conversion of heat into mechanical energy, solar thermal power generation.		**5**
	UNIT V: 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.		**6**
	UNIT VI: Solar Photocatalysis: Mechanism, kinetics, performance parameters, applications, recent advances in solar energy technologies.		**5**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

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Course Code: ME 4772	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Cryogenics Engineering (ME 4772)		
Course Objectives	• To get the knowledge on the properties of both matter and fluid for better design of the process equipment in cryogenics application • To understand the gas liquefaction and refrigeration system • Instrumentation in cryogenic system is essential for measuring properties at low temperature • Safety in cryogenics is highly important for handling liquids or cryogens environment.		

Course Outcomes		**Cognitive Levels**
CO1	The knowledge on the properties of both matter and fluid for better design of the process engineering in cryogenics application.	Analysis/Comprehension (Level IV/Level-II)
CO2	Understanding the gas separation system and able to calculate the no of plates require for the gas separation process at low temperatures.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Instrumentation in cryogenic system is essential for measuring properties at low temperature	Application/Analysis (Level-III/Level-IV)
CO4	Understand the importance of the storage and transfer systems of the cyrogens (LOx, LN2, LH2, LHe)	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Safety in cryogenics is highly important for handling liquids or cryogens environment.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Refrigeration and Air Conditioning (ME 3604)				

Text Books		
1.	Title	Cryogenics Systems
	Author	Randall F. Barron
	Publisher	Oxford Univesity Press New York
	Edition	2nd Edition
2.	Title	Refrigeration and Air Conditioning
	Author	C P Arora
	Publisher	McGraw Hill Education
	Edition	3rd Edition

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Reference Books			
1.	Title	Cryogenic Process Engineering	
	Author	Klaus D. Timmerhaus, Thomas M. Flynn	
	Publisher	Springer New York, NY	
	Edition	1st Edition	
Course Contents	**UNIT I:** 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.		**10**
	UNIT II: 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.		**10**
	UNIT III: Cryogenic Instrumentation – Properties characterizing cryogenic instrumentation, temperature, pressure, liquid level, displacement and position.		**8**
	UNIT IV: Storage and Transfer Systems – Insulation concepts, storage systems for cryogenic liquids, transfer systems, industrial storage and transfer, safety of the cryogenics system.		**8**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4773	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Experimental Methods in Mechanical Engineering (ME 4773)		
Course Objectives	• To introduce students to the fundamentals of engineering experimentation and problem-solving techniques. • To develop understanding of measurement systems, including performance characteristics and calibration methods. • To equip students with tools for analyzing experimental data, handling errors, and applying statistical methods. • To familiarize students with various measurement techniques for physical quantities like force, pressure, flow, and temperature.		

	• To enable students to design, plan, and execute experimental projects using data acquisition and processing systems.

Course Outcomes		**Cognitive Levels**
CO1	Explain the fundamentals of engineering experimentation and measurement systems.	Analysis/Comprehension (Level IV/Level-II)
CO2	Evaluate static performance characteristics of measurement systems.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Analyze experimental data using statistical and uncertainty methods.	Application/Analysis (Level-III/Level-IV)
CO4	Apply measurement techniques for force, pressure, flow, strain, and temperature.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Design and execute experiments using data acquisition systems.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Experimental Methods for Engineers
	Author	J.P. Holman
	Publisher	McGraw-Hill
	Edition	9th Edition
2.	Title	Mechanical Measurements
	Author	S.P.Venkateshan
	Publisher	Ane Books
	Edition	2ndEdition

Reference Books		
1.	Title	Mechanical Measurements
	Author	Thomas Beckwith, Roy Marangoni
	Publisher	Pearson
	Edition	2ndEdition

Course Contents		
	Unit 1: 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.	**8**
	Unit 2: Measurement System and Performance **-** Measurement system performance characteristics, static performance characteristics, static	**8**

	calibration, linearity, static sensitivity, repeatability, hysteresis, threshold, resolution, readability, and span.	
	Unit 3: 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.	**8**
	Unit 4: 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.	**8**
	Unit 5: 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.	**4**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4774	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Design of Transmission Elements (ME 4774)		
Course Objectives	• To introduce the concept, procedures, and data to analyze machine elements in power transmission systems. • To understand the design of flexible transmission systems • To apply principles of design and analyze the forces in mechanical power transmission elements such gears, clutches, brakes etc.		

Course Outcomes		**Cognitive Levels**
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	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand the design of spur gears	Knowledge/Analysis (Level-I/Level-IV)
CO3	To understand the design of bevel and helical gears	Application/Analysis (Level-III/Level-IV)
CO4	To understand the design of a gear box	Synthesis/Evaluation (Level-V/Level-VI)

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CO5	To analyze and design the power transmission mechanisms in cams, clutches and brakes				Application/Analysis (Level-III/Level-IV)
Semester	**VII**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Design of Machine Elements			
	Author	V B Bhandari			
	Publisher	McGraw Hill			
	Edition	5th Edition			
2.	Title	Shigley's Mechanical Engineering Design			
	Author	Richard G. Budynas, J. Keith Nisbett, Kiatfa Tangchaichit			
	Publisher	McGraw Hill			
	Edition	11th Edition			
Reference Books					
1.	Title	Machine Design: An Integrated Approach			
	Author	Robert L Norton			
	Publisher	Pearson Education India			
	Edition	5th Edition			
Course Contents	**UNIT I**: **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.				**6**
	UNIT II: Spur gears and Parallel Axis Helical gears peed 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.				**8**
	UNIT III: 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.				**8**
	UNIT IV: Gear boxes				**6**

	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.	
	UNIT V: 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.	**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4775	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	**Y**

Type of Course	Theory Course
Course Title & Code	Advanced Finite Element Methods (ME 4775)
Course Objectives	• To get familiarize with the time dependent problems, handling nonlinearity and the various procedures involving in solving non-linear problems. • To be able to implement the advanced FEM procedures

Course Outcomes		**Cognitive Levels**
CO1	To be able to understand and implement time stepping procedures in FEM	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand non-linearity and the iterative procedures	Knowledge/Analysis (Level-I/Level-IV)
CO3	To understand material nonlinearity and implement the basic 1D nonlinear FEM code	Application/Analysis (Level-III/Level-IV)
CO4	To understand displacement- and force-controlled setup, introduce to arc-length methods, the various methodologies involved in solving buckling problems	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Introduction to FEM (ME 3676)				

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Text Books			
1.	Title	Finite Element Procedures	
	Author	Klaus - Jurgen Bathe	
	Publisher	PHI Learning Pvt. Ltd.	
	Edition	1996	
2.	Title	Nonlinear Solid Mechanics: Theoretical Formulations and Finite Element Solution Methods	
	Author	Adnan Ibrahimbegovic	
	Publisher	1st Edition, 2009	
	Edition	Springer Dordrecht	
Reference Books			
1.	Title	Nonlinear Finite Element Analysis of Solids and Structures	
	Author	René de Borst, Mike Crisfield, Joris Remmers, Clemens Verhoosel	
	Publisher	John Wiley & Sons Ltd	
	Edition	2nd Edition, 2012	
Course Contents	**UNIT I:** Time dependent problems with explicit and implicit time integration schemes for solid and heat transfer problems		**9**
	UNIT II: Introduction to non-linearity in 1D problems, Weak formulation, Linearization, Newton-Raphson procedures		**9**
	UNIT III: Introduction to 1D inelasticity, FEM procedures for 1D inelastic problems		**9**
	UNIT IV: FEM for buckling, post-buckling procedures in frame structures		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4776	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Introduction to Mechanical Micro-Machining (ME 4776)		
Course Objectives	• To understand the fundamentals of atomic structure and scaling laws relevant to mechanical micro machining and their impact on material behavior at micro scales. • To study the principles, mechanisms, and challenges of mechanical micro machining, including burr formation, surface roughness, and built-up edge phenomena.		

	• To explore the design and fabrication of micro tools and miniature machine tools, along with the role of process parameters like cutting fluids, tool run-out, and grain size. • To introduce advanced micro machining technologies and metrology, including diamond turning processes and measurement techniques for micro-scale manufacturing.

Course Outcomes		**Cognitive Levels**
CO1	Comprehend and analyze atomic-scale phenomena, scaling laws, and their influence on mechanical micro machining processes.	Analysis/Comprehension (Level IV/Level-II)
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.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Apply and analyze the fabrication of micro cutting tools, structure of micro machine tools, and their functional integration in machining processes.	Application/Analysis (Level-III/Level-IV)
CO4	Evaluate and synthesize precision machining techniques like diamond turning and advanced metrology used in micro-scale manufacturing.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Micro-Cutting: Fundamentals and Applications
	Author	Cheng, Huo,
	Publisher	Wiley Publication, 2013
	Edition	1st Edition
2.	Title	Introduction to Micromachining
	Author	V. K. Jain
	Publisher	Narosa Publishing House, 2014
	Edition	2nd Edition
Reference Books		
1.	Title	Precision Manufacturing
	Author	David Dornfeld and Dae-Eun Lee
	Publisher	Springer US, 2008
	Edition	1st Edition

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Course Contents	**UNIT I**: Experimental observations and theoretical prediction of constituents of an atom. Scaling law.	**9**
	UNIT II: Mechanical micro machining (process, mechanism). Burr formation, surface roughness, built up edge.	**9**
	UNIT III: Cutting fluid, run out, grain size. Micro machine structure. Fabrication of micro cutting tools.	**9**
	UNIT IV: Miniature machine tools. Diamond Turning (process, types, mechanism, applications). Metrology for micro machining.	**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4777	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y

Type of Course	Theory Course
Course Title & Code	Introduction to Computational Fluid Dynamics (ME 4777)
Course Objectives	• To develop skills in computational fluid dynamics to address engineering problems. • To understand the basic structure and capabilities of current commercial CFD codes

Course Outcomes		**Cognitive Levels**
CO1	Explain various methods of CFD and compare with experimental and theoretical analysis	Knowledge/Comprehension (Level-I/Level-II)
CO2	Formulate the governing equations and solve the numerical problem.	Analysis/Synthesis (Level-IV/Level-V)
CO3	Derive finite volume method and apply to 2-D and 3-D problems	Application/Analysis (Level-III/Level-IV)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	Fluid Mechanics (ME2304)
Text Books	

1.	Title	Computational Fluid Mechanics and Heat Transfer

	Author	J.E Tannehill, D.A Anderson and R.H. Pletcher,	
	Publisher	Taylor & Francis, 1997.	
	Edition	2nd Edition	
2	Title	Computational Fluid Dynamics for Engineers, Engineering Education Systems	
	Author	K.A. Hoffmann, and S.T Chiang,.	
	Publisher	Taylor and Francis 2000.	
	Edition	4th Edition	
Reference Books			
1.	Title	Computational Fluid Dynamics – The basics with applications.	
	Author	J.D Andeson	
	Publisher	Mc Grew Hill, 1995.	
	Edition	1st Edition	
2.	Title	An Introduction to Computational Fluid Dynamics – The finite volume method	
	Author	H.K. Versteeg, and W.Malalasekera, Longma	
	Publisher	Scientific & Technical, 1995.	
	Edition	1st Edition	
3.	Title	Numerical Heat Transfer & Fluid Flow	
	Author	S.V. Patankar, Hemisphere	
	Publisher	CRC Press, 1980	
	Edition	1st Edition	
Course Contents	**UNIT I**: Classification of partial differential equations - Discretization methods; finite difference and finite volume formulations. Numerical solution of elliptical equations;		**14**
	UNIT II: - Linear system of algebraic equations. Numerical solution of parabolic equations - Stability analysis. Numerical solution of hyperbolic equations - Burgers equation. .		**12**
	UNIT III: Incompressible Navier-Stokes equations and algorithms - Basics of grid generation.		**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

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Course Code: ME 4778	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Additive Manufacturing (ME 4778)		
Course Objectives	• Development of Additive Manufacturing (AM), classifications, models, and opportunities for product development and also to learn the different tools, soft-wares required and the applications of Additive Manufacturing. • Acquaint with software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM. • Familiarize with VAT polymerization and material extrusion processes, powder bed fusion and direct energy deposition. • Applications of binder jetting, material jetting and laminated object manufacturing processes		

Course Outcomes		**Cognitive Levels**
CO1	Understand the working principle and process parameters of AM processes	Analysis/Comprehension (Level IV/Level-II)
CO2	Explore the applications of AM processes in various fields	Knowledge/Analysis (Level-I/Level-IV)
CO3	Apply the suitable process and material for fabricating a given product	Application/Analysis (Level-III/Level-IV)
CO4	Use the suitable post process based on product application	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Design and develop a product for AM Process	Application/Analysis (Level-III/Level-IV)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing
	Author	Ian Gibson, David W. Rosen, and Brent Stucker
	Publisher	Springer, 2015
	Edition	2nd Edition
2.	Title	3D Printing and Additive Manufacturing: Principles & Applications

	Author	Chua Chee Kai, Leong Kah Fai, and C.S. Lim	
	Publisher	World Scientific, 2015	
	Edition	4th Edition	
1.	Title	Rapid Prototyping: Laser-based and Other Technologies	
	Author	Patri K. Venuvinod and Weiyin Ma,	
	Publisher	Springer, 2004.	
	Edition	2nd Edition	
2.	Title	Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling,	
	Author	D.T. Pham, S.S. Dimov,	
	Publisher	Springer, 2001	
	Edition	3rd Edition	
Course Contents	**UNIT I**: **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).		**8**
	UNIT II: **Liquid state-based 3D printing Process:** Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, Micro-stereolithography, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. **Solid ground curing (SGC):** Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.		**8**
	UNIT III: Solid state-based 3D printing Processes: Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. **Fused Deposition Modeling (FDM**): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration. **Additive friction stir deposition process:** principle, parameters, applications, functionally graded additive manufacturing components, Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC		**10**

	applications. Wire Arc Additive Manufacturing: Process, parameters, applications, advantages and disadvantages, case studies.	
	UNIT IV: **Powder Based 3D printing Processes:** Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes. **Directed Energy Deposition Processes:** Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes, case studies, Binder Jetting AM Process: process, applications **Additive Manufacturing Printing Applications**: Industrial Applications in aerospace, automobile, medical, jewelry, sports, electronics, food, construction and architectural. **Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement,	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

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Course Code: ME 4871	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y

Type of Course	Theory Course
Course Title & Code	Failure Analysis and Design (ME 4871)
Course Objectives	• Familiarize with various failure modes of engineering components • Impart knowledge of wear and corrosion

Course Outcomes		**Cognitive Levels**
CO1	Recognize and describe common engineering failure mechanisms	Analysis/Comprehension (Level IV/Level-II)
CO2	Predict the remaining useful life of the components using fatigue, fracture and creep	Knowledge/Analysis (Level-I/Level-IV)
CO3	Understand the various aspects of wear and corrosion	Application/Analysis (Level-III/Level-IV)
CO4	Analyze the failed engineering components	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books

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

Reference Books

1.	Title	ASM Handbook, Vol. 11, "Failure Analysis and Prevention"
	Author	Brett A. Miller, Roch J. Shipley, Ronald J. Parrington, and Daniel P. Dennies
	Publisher	ASM Publications

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	Edition	10th Edition, 2002	
Course Contents	**UNIT I** 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.		**9**
	UNIT II 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.		**13**
	UNIT III Wear failures, adhesive, abrasive, erosive, corrosive wear. Elevated temperature failures, creep, creep crack branching. Corrosion failures, types and their identification.		**8**
	UNIT IV Application and case studies on Failure analysis: Failures of cast and welded components, failures of rotating components-shaft, bearing and gears.		**6**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4872	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Convective Heat Transfer (ME 4872)		
Course Objectives	• To apply the physical principles and governing equations of convective heat transfer. • To analyze and solve problems involving forced convection in internal and external flows. • To evaluate heat transfer characteristics in natural convection systems. • To apply convective heat transfer principles in real-world engineering systems.		

Course Outcomes		**Cognitive Levels**
CO1	To gain an understanding of the fundamental theories of convective heat transfer.	Analysis/Comprehension (Level II/Level-III)
CO2	To analyze heat transfer in external forced convection scenarios.	Knowledge/Analysis (Level-III/Level-V)
CO3	To develop the skills to evaluate heat transfer in internal forced convection scenarios.	Application/Analysis (Level-IV/Level-V)

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CO4	To apply the concepts of natural and mixed convection to practical engineering problems.				Synthesis/Evaluation (Level-V/Level-VI)
Semester	**VIII**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Heat and Mass Transfer (ME 3501)				
Text Books					
1.	Title	Convection Heat Transfer			
	Author	Adrain Bejan			
	Publisher	Wiley & Sons			
	Edition	4th Edition			
Reference Books					
1.	Title	Incropera's Principles of Heat and Mass Transfer			
	Author	Frank P. Incropera, David P. Dewitt, Theodore L. Bergman, Adrienne S. Lavine			
	Publisher	Wiley & Sons			
	Edition	1st Edition			
Course Contents	**UNIT I**: Introduction: Classification, Governing equations, Dimensional analysis and similarity parameters, Boundary layers: thermal and velocity, Blasius solution				**9**
	UNIT II: 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.				**9**
	UNIT III: 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.				**9**
	UNIT IV: 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				**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%				

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Course Code: ME 4873	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Introduction to Solidification Processing (ME 4873)		
Course Objectives	• To analyze the thermodynamics and kinetics of nucleation and growth during solidification. • To identify the role of heat transfer and interface movement in solidification processes. • To evaluate defects formed during solidification and methods to control them. • To apply solidification principles to various manufacturing processes like casting and welding.		

Course Outcomes		**Cognitive Levels**
CO1	To gain an understanding of the fundamental principles and theories underlying the solidification process.	Analysis/Comprehension (Level V/Level-III)
CO2	To be able to analyze the solidification behavior of pure metals and alloys, including microstructure development	Knowledge/Analysis (Level-III/Level-II)
CO3	To be able to develop the skills to identify common solidification defects and implement strategies to control and prevent them	Application/Analysis (Level-IV/Level-III)
CO4	To be able to identify and evaluate the diverse applications of microfluidics.	Synthesis/Evaluation (Level-IV/Level-V)

Semester	**VIII**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	Heat and Mass Transfer (ME 3501) Materials Engineering (ME 2301)

Text Books		
1.	Title	Principles of Solidification: An Introduction to Modern Casting and Crystal Growth Concepts
	Author	Martin Eden Glicksman
	Publisher	Springer
	Edition	1st Edition

Reference Books		
1.	Title	Phase Transformations In Metals And Alloys
	Author	David A Porter, Kenneth E Easterling, Mohamed Y Sherif
	Publisher	CRC Press

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	Edition	3rd Edition
Course Contents	**UNIT I**: Fundamentals of Solidification: Overview, Thermodynamics of phase transformation, Homogeneous and heterogeneous nucleation, Growth of crystals: planar, cellular, dendritic.	**9**
	UNIT II: 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.	**9**
	UNIT III: 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.	**9**
	UNIT IV: Advanced Topics in Solidification: Rapid Solidification, Directional Solidification, Solidification in Additive Manufacturing, Future Trends and Innovations	**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4874	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Renewable Energy Engineering (ME 4874)		
Course Objectives	• To introduce students to various forms of renewable energy and their global significance. • To impart fundamental knowledge of solar thermal and photovoltaic systems, including energy conversion and applications. • To explain biomass resources and bioenergy conversion technologies for sustainable fuel production. • To develop understanding of wind energy systems and their components, performance, and applications. • To provide insight into emerging renewable technologies like geothermal, tidal, fuel cells, and MHD systems.		

Course Outcomes		**Cognitive Levels**
CO1	Understand and evaluate the potential and utilization of solar energy systems for different applications.	Analysis/Comprehension (Level IV/Level-II)
CO2	Analyze and compare biomass conversion techniques and assess bioenergy systems.	Knowledge/Analysis (Level-I/Level-IV)

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CO3	Interpret wind data and design basic wind energy systems for practical applications.	Application/Analysis (Level-III/Level-IV)
CO4	Identify and describe working principles of geothermal, tidal, and other advanced renewable technologies.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Apply the principles of renewable energy systems in real-world problem-solving and sustainable energy planning.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Applied Thermodynamics (ME 2401) Heat and Mass Transfer (ME 3501)				

Text Books		
1.	Title	Solar Energy: Principles of Thermal Collection and Storage
	Author	S. P. Sukhatmeand J. K. Nayak
	Publisher	Tata McGraw Hill
	Edition	3rd edition
2.	Title	Energy Technology - Nonconventional, Renewable and Conventional
	Author	Rao, S. and Parulekar
	Publisher	R.BKhanna Publishers
	Edition	1st Edition
Reference Books		
1.	Title	Wind Power Plant - Theory and Design
	Author	Le Gourieres, D
	Publisher	Pergaman Press
	Edition	1st Edition

Course Contents	**Unit I:** 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.	**10**
	Unit II: 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.	**8**
	Unit III: 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	**8**

	performance of windmills, grid-connected and standalone systems, applications in rural and small-scale energy supply.	
	Unit IV: 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.	**10**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME4875	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Non-Traditional Machining (ME 4875)		
Course Objectives	• To understand the classification, principles, and applications of various unconventional machining processes including mechanical, thermal, and electrochemical types. • To study the mechanisms and process parameters of non-traditional techniques such as EDM, ECM, LBM, AJM, USM, and their allied processes. • To explore advanced finishing processes like abrasive flow, magnetic abrasive, and chemo-mechanical polishing, and understand their precision capabilities. • To develop analytical and numerical modeling skills, along with computer-aided process planning techniques, for optimizing non-traditional machining operations.		

Course Outcomes		**Cognitive Levels**
CO1	Comprehend and analyze various unconventional machining processes including their classification, mechanism, and applications.	Analysis/Comprehension (Level IV/Level-II)
CO2	Identify and analyze the working principles, tool design, and process parameters of processes like EDM, ECM, LBM, and USM.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Apply and analyze advanced surface finishing techniques for achieving high-precision components.	Application/Analysis (Level-III/Level-IV)

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CO4	Evaluate and synthesize analytical/numerical models and computer-aided process planning strategies for optimizing non-traditional machining processes.				Synthesis/Evaluation (Level-V/Level-VI)
Semester	**VIII**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Nontraditional Manufacturing Processes			
	Author	Gary F. Benedict			
	Publisher	Taylor & Francis			
	Edition	1987			
2.	Title	Modern Machining Processes			
	Author	P. C. Pandey and H. S. Shan			
	Publisher	Tata McGraw-Hill Education,			
	Edition	1980			
Reference Books					
1.	Title	Advanced Machining Processes			
	Author	V. K. Jain			
	Publisher	Allied Publishers,			
	Edition	2009.			
Course Contents	**UNIT I**: 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;				**12**
	UNIT II: Electro chemical machining (ECM) and allied processes, ECM tool design, chemical machining, photochemical machining; Elastic emission machining;				**6**
	UNIT III: 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;				**12**
	UNIT IV: Numerical modelling and simulation of unconventional machining processes; Computer aided process planning of non-traditional machining processes.				**6**

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Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: ME 4876	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Green Manufacturing (ME 4876)		
Course Objectives	• To understand the environmental impacts of design and manufacturing, including inefficient energy use, pollution, and material waste, and promote sustainable product development. • To study eco-friendly material selection and recycling techniques, along with mass balance analysis and green indicators for sustainable process planning. • To introduce the concepts of eco-design and industrial ecology, focusing on pollution prevention, disassembly, and design for recyclability. • To explore renewable energy resources and full-cost accounting methodologies to assess the environmental and economic impact of materials and processes in manufacturing.		

Course Outcomes		**Cognitive Levels**
CO1	Comprehend and analyze the environmental effects of design, inefficient energy usage, and need for recycling-oriented product development.	Analysis/Comprehension (Level IV/Level-II)
CO2	Identify and analyze material flow cycles, recycling practices, and mass balance analysis in achieving emission-less manufacturing.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Apply and analyze green manufacturing strategies including design for disassembly, risk assessment, and eco-design principles.	Application/Analysis (Level-III/Level-IV)
CO4	Evaluate and synthesize the use of renewable energy systems and environmentally friendly materials using full-cost accounting approaches.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**	**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Syllabus of Departmental Elective IV Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Text Books			
1.	Title	Costing the earth	
	Author	Cairncrss and Francis	
	Publisher	Harvard Business School Press, 1992	
	Edition	2nd Edition	
2.	Title	Industrial Ecology	
	Author	Gradel.T.E. and B.R. Allenby	
	Publisher	Prentice Hall, 2003	
	Edition	2nd Edition	
Reference Books			
1.	Title	Our Common Future	
	Author	World commission on Environment and Development (WCED),	
	Publisher	Oxford University Press, 1987	
	Edition	1st Edition	
Course Contents	**UNIT I**: Environmental effects of design – Environmental damage – In efficient energy use – Design for recycling.		**8**
	UNIT II: Material flow and cycles – Material recycling – Emission less manufacturing.		**8**
	UNIT III: 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.		**12**
	UNIT IV: Solar energy devices – wind energy resources – Full cost accounting methodology – Selection of natural friendly materials.		**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4877	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Reliability Analysis and Materials Management (ME 4877)		

Syllabus of Departmental Elective IV Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Objectives	• Introduce students to concepts of system reliability, failure modes, and probabilistic methods for analyzing the dependability of engineering systems. • Provide knowledge of inventory control, procurement strategies, storage, and supply chain coordination for effective materials handling in manufacturing and service sectors. • Enable students to apply reliability models and materials planning tools (like EOQ, MRP, and ABC analysis) for efficient resource utilization and risk minimization.

Course Outcomes		**Cognitive Levels**
CO1	Understand and comprehend the fundamentals of reliability analysis of engineering components and systems.	Analysis/Comprehension (Level IV/Level-II)
CO2	Explain and describe the modus operandi for replacement or repair, maintenance, inspection and quality control.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Identify and investigate the system depicting the probable causes of failure and needs for maintenance.	Application/Analysis (Level-III/Level-IV)
CO4	Design and analyse the component or system based on reliability analysis.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**	**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

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

Reference Books		
1.	Title	Practical Reliability Engineering
	Author	Patrick D. T. O'Connor
	Publisher	Wiley, 2008
	Edition	4th Edition

Syllabus of Departmental Elective IV Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

2.	Title	Life Cycle Reliability Engineering	
	Author	Guang Yang, 2007	
	Publisher	Wiley	
	Edition	1st Edition	
Course Contents	**UNIT I:** 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.		**8**
	UNIT II: 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.		**10**
	UNIT III: 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.		**8**
	UNIT IV: 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.		**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4878	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	N	N	Y
Type of Course	Theory Course		
Course Title & Code	Product innovation and Start – up Strategies (ME 4878)		

Syllabus of Departmental Elective IV Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Objectives	• Enable students to understand and apply design thinking and innovative processes to develop user-centric product ideas. • Provide knowledge of startup development strategies, including business model creation, lean startup methodology, and market analysis. • Build competency in navigating funding options, legal aspects, and scalability issues involved in launching and growing a sustainable startup.

Course Outcomes		**Cognitive Levels**
CO1	Understand and explain key concepts of innovation, entrepreneurship, and the startup ecosystem.	Analysis/Comprehension (Level IV/Level-II)
CO2	Apply design thinking and ideation techniques to develop innovative product ideas and solutions.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Construct viable business models using tools like the Business Model Canvas.	Application/Analysis (Level-III/Level-IV)
CO4	Analyze market needs, customer segments, and value propositions for proposed startups.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Evaluate funding sources, legal aspects, and operational strategies required for launching a startup	Application/Analysis (Level-III/Level-IV)
CO6	Develop and present a comprehensive startup plan including product strategy, business model, and go-to-market approach.	Knowledge/Analysis (Level-I/Level-IV)

Semester	**VIII**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books

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

Reference Books

Syllabus of Departmental Elective IV Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

1.	Title	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses	
	Author	Eric Ries,	
	Publisher	Crown Business, 2011.	
	Edition	1st Edition	
2.	Title	Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School	
	Author	Idris Mootee	
	Publisher	Wiley, 2013.	
	Edition	1st Edition	
3.	Title	Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers	
	Author	Alexander Osterwalder & Yves Pigneur,	
	Publisher	Wiley, 2010.	
	Edition	1st Edition	
Course Contents	**UNIT I: 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.		**8**
	UNIT II: 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.		**10**
	UNIT III: 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.		**8**
	UNIT IV: 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.		**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Syllabus of Departmental Elective IV Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

<table>
<tr><td rowspan="2">Course Code:
ME 4879</td><td>Open Elective Course: (Y/N)</td><td>Departmental Core Course: (Y/N)</td><td>Departmental Elective Course: (Y/N)</td></tr>
<tr><td>N</td><td>N</td><td>Y</td></tr>
<tr><td>Type of Course</td><td colspan="3">Theory Course</td></tr>
<tr><td>Course Title & Code</td><td colspan="3">Project Management (ME 4879)</td></tr>
<tr><td>Course Objectives</td><td colspan="3">• To introduce students to the core concepts, life cycle, and methodologies of project management, including planning, scheduling, budgeting, and resource allocation
• To equip students with tools and techniques such as CPM, PERT, and risk analysis for effective project planning, monitoring, and control.
• To foster skills in leadership, teamwork, and communication essential for managing multidisciplinary project teams and stakeholder expectations.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="2">Cognitive Levels</td></tr>
<tr><td>CO1</td><td colspan="2">Understand the importance of projects and its phases.</td><td colspan="2">Analysis/Comprehension (Level IV/Level-II)</td></tr>
<tr><td>CO2</td><td colspan="2">Evaluate projects based on discount and non-discount methods.</td><td colspan="2">Knowledge/Analysis (Level-I/Level-IV)</td></tr>
<tr><td>CO3</td><td colspan="2">Apply crashing procedures for time and cost optimization.</td><td colspan="2">Application/Analysis (Level-III/Level-IV)</td></tr>
<tr><td>CO4</td><td colspan="2">Analyse projects from marketing, operational and financial perspectives.</td><td colspan="2">Synthesis/Evaluation (Level-V/Level-VI)</td></tr>
<tr><td>CO5</td><td colspan="2">Develop network diagrams for planning and execution of a given project.</td><td colspan="2">Knowledge/Analysis (Level-I/Level-IV)</td></tr>
<tr><td colspan="2">Semester</td><td colspan="2">VIII</td><td colspan="2">EVEN</td></tr>
<tr><td colspan="2" rowspan="2">Contact Hours</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Credits</td><td>Total Teaching Hours</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>36</td></tr>
<tr><td colspan="2">Prerequisite course codes with course names</td><td colspan="5">NA</td></tr>
<tr><td colspan="7">Text Books</td></tr>
<tr><td rowspan="4">1.</td><td>Title</td><td colspan="5">Project: A Planning Analysis</td></tr>
<tr><td>Author</td><td colspan="5">Prasanna Chandra</td></tr>
<tr><td>Publisher</td><td colspan="5">Tata McGraw Hill Book Company</td></tr>
<tr><td>Edition</td><td colspan="5">4th Edition</td></tr>
<tr><td rowspan="3">2.</td><td>Title</td><td colspan="5">Project Management</td></tr>
<tr><td>Author</td><td colspan="5">Cleland, Gray and Laudon</td></tr>
<tr><td>Publisher</td><td colspan="5">Tata McGraw Hill Book Company</td></tr>
</table>

	Edition	3rd Edition	
3.	Title	Project Management - A Managerial Approach	
	Author	Jack R. Meredith and Samuel J., Jr. Mantel	
	Publisher	John Wiley, 2011	
	Edition	6th Edition.	
Reference Books			
1.	Title	The Critical Chain	
	Author	Eliyahu M Goldratt	
	Publisher	Business novel, 1997	
	Edition	4th Edition	
2.	Title	A guide to the Project Management Body of Knowledge	
	Author	Project Management Institute (PMI)	
	Publisher	Project Management Institute, Inc. 2008	
	Edition	4th Edition	
Course Contents	**UNIT I**: 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.		**8**
	UNIT II: 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.		**10**
	UNIT III: Optimization in PM: Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.		**8**
	UNIT IV: Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.		**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

<table>
<tr><td rowspan="2">Course Code:
ME 4750</td><td>Open Elective Course: (Y/N)</td><td>Departmental Core Course: (Y/N)</td><td>Departmental Elective Course: (Y/N)</td></tr>
<tr><td>Y</td><td>N</td><td>N</td></tr>
<tr><td>Type of Course</td><td colspan="3">Theory Course</td></tr>
<tr><td>Course Title & Code</td><td colspan="3">Sustainable Engineering (ME 4750)</td></tr>
<tr><td>Course Objectives</td><td colspan="3">• To introduce students to the fundamental concepts of sustainability and the role of engineering in sustainable development.
• To develop an understanding of environmental pollution, climate change, and legal frameworks for environmental protection.
• To familiarize students with carbon capture technologies such as amine-based systems and direct air capture (DAC).
• To provide knowledge of renewable and sustainable energy systems from a mechanical engineering perspective.
• To encourage sustainable design thinking and the application of tools like LCA, EIA, and green engineering in real-world scenarios.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="2">Cognitive Levels</td></tr>
<tr><td>CO1</td><td colspan="2">Explain the key principles of sustainability and analyze how engineering practices influence sustainable development.</td><td>Analysis/Comprehension (Level IV/Level-II)</td></tr>
<tr><td>CO2</td><td colspan="2">Assess environmental pollution issues and identify strategies for pollution control and carbon mitigation.</td><td>Knowledge/Analysis (Level-I/Level-IV)</td></tr>
<tr><td>CO3</td><td colspan="2">Evaluate various carbon capture techniques, including DAC and amine-based methods, for industrial applications.</td><td>Application/Analysis (Level-III/Level-IV)</td></tr>
<tr><td>CO4</td><td colspan="2">Describe and compare different renewable energy sources and their integration into sustainable systems.</td><td>Synthesis/Evaluation (Level-V/Level-VI)</td></tr>
<tr><td>CO5</td><td colspan="2">Apply sustainability tools such as LCA, EIA, and ISO standards in the design and evaluation of engineering projects.</td><td>Synthesis/Evaluation (Level-V/Level-VI)</td></tr>
<tr><td colspan="2">Semester</td><td colspan="2">VII</td><td>ODD</td></tr>
<tr><td rowspan="2">Contact Hours</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Credits</td><td>Total Teaching Hours</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>36</td></tr>
<tr><td>Prerequisite course codes with course names</td><td colspan="4">Engineering Mathematics –II (MA 1201)
Environmental Sustainability (CE 1201)</td></tr>
<tr><td colspan="5">Text Books</td></tr>
</table>

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

1.	Title	Sustainability Engineering: Concepts, Design and Case Studies	
	Author	Allen, D. T. and Shonnard, D. R.	
	Publisher	Pearson Education, 2011	
	Edition	1st Edition	
2.	Title	Engineering Applications in Sustainable Design and Development	
	Author	Bradley A. Striebig, Adebayo A. Ogundipe, Maria Papadakis	
	Publisher	Cengage Learning, 2016	
	Edition	1st Edition	
Reference Books			
1.	Title	Carbon Capture	
	Author	Jennifer Wilcox	
	Publisher	Springer, 2012	
	Edition	1st Edition	
Course Contents	**Unit I:** 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.		**8**
	Unit II: 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.		**8**
	Unit III: 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.		**8**
	Unit IV: 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.		**8**
	Unit V: 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.		**4**

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%

Course Code: ME 4751	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N

Type of Course	Theory Course
Course Title & Code	Optimization in Engineering (ME 4751)
Course Objectives	• To understand the importance of optimization in engineering • To understand and analyze the different algorithms involved in optimization procedures. • To impart knowledge on the various evolutionary algorithms in optimization

Course Outcomes		**Cognitive Levels**
CO1	To get an understanding and formulate optimization problems in engineering	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand and solve single variable optimization problems	Knowledge/Analysis (Level-I/Level-IV)
CO3	To understand and solve multi-variable optimization problems	Application/Analysis (Level-III/Level-IV)
CO4	To understand and solve optimization problems with constraints	Synthesis/Evaluation (Level-V/Level-VI)
CO5	To understand evolutionary based optimizations procedures	Knowledge/Analysis (Level-I/Level-IV)

Semester	**VII**	**ODD**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books

1.	Title	Engineering Optimization: Theory and Practice
	Author	Singiresu S. Rao
	Publisher	New Age International Private Limited
	Edition	4th Edition
2.	Title	Optimization for Engineering Design: Algorithms and Examples

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

	Author	Kalyanmoy Deb	
	Publisher	Prentice Hall India Learning Private Limited	
	Edition	1st Edition, 1995	
Reference Books			
1.	Title	An Introduction To Optimization	
	Author	Edwin K. P. Chong and Stanislaw H. Zak	
	Publisher	Wiley	
	Edition	4th Edition	
Course Contents	**UNIT I**: **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.		**3**
	UNIT II: Single-variable Optimization Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.		**7**
	UNIT III: 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		**10**
	UNIT IV: Constrained Optimization KKT conditions, Penalty method, and Sensitivity analysis, direct search methods for constrained optimization, quadratic programming, Formulation, and Case studies		**8**
	UNIT V: Evolutionary Optimization algorithm Genetic algorithms, simulated annealing, Anti-colony optimization, Particle swarm optimization		**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4752	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Elements of Product Design (ME 4752)		
Course Objectives	• To understand the different stages and the different aspects needed to be considered in the product development • To impart knowledge on intellectual properties and patenting • To formulate the financial aspects in product design life cycle		

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Outcomes		**Cognitive Levels**
CO1	To be able to understand the basic aspects involved in product design	Analysis/Comprehension (Level IV/Level-II)
CO2	To be able to understand value engineering and Design For X (DFX),	Knowledge/Analysis (Level-I/Level-IV)
CO3	To get familiarize with the importance and procedures to intellectual property rights and patenting	Application/Analysis (Level-III/Level-IV)
CO4	To be able to understand the importance and steps involved in reverse engineering and prototyping	Synthesis/Evaluation (Level-V/Level-VI)
CO5	To be able to formulate and layout the economics in product development	Knowledge/Analysis (Level-I/Level-IV)

Semester	**VII**	**ODD**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books		
1.	Title	Product design and development
	Author	Karl Ulrich, Steven Eppinger, Maria C. Yang
	Publisher	McGraw-Hill Education
	Edition	6th Edition
2.	Title	Product Design: Techniques in Reverse Engineering and New Product Development
	Author	Kevin Otto and Kristin Wood
	Publisher	Prentice Hall
	Edition	1st Edition, 2001
Reference Books		
1.	Title	Integrated product and process design and development
	Author	Edward B. Magrab, Satyandra K. Gupta, F. Patrick McCluskey, Peter Sandborn
	Publisher	CRC Press
	Edition	2th Edition, 2009
2	Title	Reverse Engineering: An Industrial Perspective
	Author	Vinesh Raja and Kiran J. Fernandes
	Publisher	Springer London
	Edition	1st Edition, 2008

Course Contents	**UNIT I**: **Introduction** Introduction to product design and manufacturing, Product design morphology, Visual Design, and Quality Function Deployment (QFD)	**3**

	UNIT II: Value Engineering and DFX Value Engineering, Material, and Manufacturing process selection, Design for Manufacturing, Assembly, and Maintenance, Design for Environment, and Quality Control	**7**
	UNIT III: Patents and Intellectual Property Understanding Intellectual Property and Patenting, Procedures to Patenting	**10**
	UNIT IV: Reverse Engineering, Prototyping Reverse methodologies and engineering steps, Understanding prototyping, Principles and planning of Prototyping	**8**
	UNIT V: Product development economics Elements of Economic Analysis, Development of a Financial model, Sensitivity analysis, Trade-Offs, Influence of quality factors	**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4753	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N

Type of Course	Theory Course
Course Title & Code	Introduction to Medical Devices and its Design (ME 4753)
Course Objectives	• Enable the students to understand the processes involved in medical device design • To learn the working principle of various medical devices

Course Outcomes		**Cognitive Levels**
CO1	An understanding on process and stages of medical device design, its clinical trials and regulation requirements in testing	Analysis/Comprehension (Level IV/Level-II)
CO2	To learn the Biopotentials considered in EMG, EOG, ECG, EEG	Knowledge/Analysis (Level-I/Level-IV)
CO3	To understand the medical diagnostics through in-vitro diagnostics and imaging.	Application/Analysis (Level-III/Level-IV)
CO4	To get knowledge on minimally invasive devices, advanced surgical tools and implants etc.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Prerequisite course codes with course names	NA		
Text Books			
1.	Title	Medical Instrumentation: Application and Design	
	Author	John G. Webster	
	Publisher	Wiley	
	Edition	4th Edition	
2.	Title	Biodesign: The Process of Innovating Medical Technologies	
	Author	Paul G. Yock, Stefanos Zenios, Josh Makower, Todd J. Brinton, Uday N. Kumar, F. T. Jay Watkins	
	Publisher	Cambridge University Press	
	Edition	2nd Edition	
Reference Books			
1.	Title	Design Controls for the Medical Device Industry	
	Author	Marie B. Teixeira	
	Publisher	CRC Press	
	Edition	3rd Edition	
2.	Title	Design of Biomedical Devices and Systems	
	Author	Paul H. King, Richard C. Fries, and Arthur T. Johnson	
	Publisher	CRC Press	
	Edition	4th Edition	
Course Contents	**UNIT I** Medical Device Classification, Bioethics and Privacy, Biocompatibility and Sterilization Techniques, Design of Clinical Trials, Design Control & Regulatory Requirements.		**9**
	UNIT II Introduction to specific medical technologies: Biopotentials measurement (EMG, EOG, ECG, EEG)		**9**
	UNIT III Medical Diagnostics (In-vitro diagnostics), Medical Diagnostics (Imaging)		**9**
	UNIT IV Minimally Invasive Devices, Surgical Tools and Implants, Medical Records and Telemedicine		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 4754	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	**N**
Type of Course	Theory Course		
Course Title & Code	Automation and Control (ME 4754)		
Course Objectives	• Enable the students to understand the principle of automation and control in engineering, its importance and applications • To learn the concepts of different elements of control units		

Course Outcomes		**Cognitive Levels**
CO1	An understanding on automation and its importance, types of automation, components of automation, strategies and levels of automation	Analysis/Comprehension (Level IV/Level-II)
CO2	Learn the constructions and working principle of different types of sensors and transducers.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Understand the constructions and working principle of different types of Actuators and drive systems.	Application/Analysis (Level-III/Level-IV)
CO4	To impart knowledge on the control elements.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	To understand the different control schemes generally used to get best output.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books

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

Reference Books

1.	Title	Handbook Of Industrial Automation
	Author	Richard Shell

	Publisher	CRC Press	
	Edition	1st Edition	
2.	Title	Introduction to Industrial Automation	
	Author	Stamatios Manesis, George Nikolakopoulos	
	Publisher	CRC Press	
	Edition	1st Edition	
Course Contents	**UNIT I** **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.		**6**
	UNIT II 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.		**9**
	UNIT III Actuators and drive systems: Mechanical, Electrical, Hydraulic drive systems, Characteristics of mechanical, Electrical, Hydraulic and pneumatic actuators and their limitations.		**8**
	UNIT IV 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		**4**
	UNIT V 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.		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4755	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Intellectual Property Rights (IPR) (ME 4755)		

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Objectives	• Understanding, defining and differentiating different types of intellectual properties (IPs) and their roles in contributing to organizational competitiveness. • Understanding the Framework of Strategic Management of Intellectual Property (IP). • Appreciating and appraising different IP management (IPM) approaches and describing how pioneering firms initiate, implement and manage IPM programs, Explaining how to derive value from IP and leverage its value in new product and service development • Exposing to the Legal management of IP and understanding of real life practice of IPM.

Course Outcomes		**Cognitive Levels**
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.	Analysis/Comprehension (Level IV/Level-II)
CO2	Recognize the crucial role of IP in organizations of different industrial sectors for the purposes of product and technology development.	Knowledge/Analysis (Level-I/Level-IV)
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.	Application/Analysis (Level-III/Level-IV)
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.	Synthesis/Evaluation (Level-V/Level-VI)
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.	Knowledge/Analysis (Level-I/Level-IV)
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;	Analysis/Comprehension (Level IV/Level-II)

Semester	**VII**		**ODD**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

1.	Title	Intellectual Property	
	Author	Deborah E. Bouchoux	
	Publisher	Cengage learning Inc Pub, 2012	
	Edition	4th Edition	
2.	Title	Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets	
	Author	Deborah E. Bouchoux,	
	Publisher	Cengage Learning, 2012	
	Edition	3rd Edition	
Reference Books			
1.	Title	Intellectual Property Rights: Unleashing the Knowledge Economy	
	Author	Prabuddha Ganguli	
	Publisher	McGraw Hill Education, 2011.	
	Edition	1st Edition	
2.	Title	Fundamentals of Intellectual Property for Engineers	
	Author	Kompal Bansal	
	Publisher	BS Publications, 2013	
	Edition	1st Edition	
Course Contents	**UNIT I**: 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.		**8**
	UNIT II: 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.		**10**
	UNIT III: 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.		**8**
	UNIT IV: 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		**10**

	a knowledge-based society. IPR and technology transfer, Amendments in the IPR case studies.	
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4756	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N

Type of Course	Theory Course
Course Title & Code	Operations Research (ME 4756)
Course Objectives	• To formulate and solve basic linear optimization problems relevant to mechanical engineering. • To analyze and optimize allocation of resources for manufacturing and production systems. • To apply network models in planning and managing engineering projects. • To analyze queuing systems and simulate operations in service and production systems.

Course Outcomes		**Cognitive Levels**
CO1	To gain an understanding of the fundamental principles and theories underlying Operations Research.	Analysis/Comprehension (Level II/Level-III)
CO2	To formulate and solve various optimization problems using linear, integer, dynamic programming techniques.	Knowledge/Analysis (Level-III/Level-V)
CO3	To apply queuing theory, inventory management and simulation techniques in practical scenarios.	Application/Analysis (Level-IV/Level-V)
CO4	To gain proficiency in planning and managing engineering projects using network models.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books		
1.	Title	Operations Research: An Introduction
	Author	Hamdy A. Taha
	Publisher	Pearson
	Edition	10th Edition

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Reference Books			
1.	Title	Operations Research: A Practical Introduction	
	Author	Michael Carter, Camille C. Price, Ghaith Rabadi	
	Publisher	CRC Press	
	Edition	2nd Edition	
Course Contents	**UNIT I**: 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.		**9**
	UNIT II: 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.		**9**
	UNIT III: 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.		**9**
	UNIT IV: 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.		**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4757	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Smart Materials (ME 4757)		
Course Objectives	• To understand the interdisciplinary material properties for sensors and actuators applications. • To familiarize the working principles of various sensors for different applications • To demonstrate the role of actuators and actuator materials. • To introduce the basic concepts of piezoelectric energy harvesting. • To discuss the various measurements and signal processing techniques for structural dynamic applications		

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Outcomes		**Cognitive Levels**
CO1	To make use of various smart materials properties for sensors and actuators applications.	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand the working of sensors for various applications.	Knowledge/Analysis (Level-I/Level-IV)
CO3	To identify the suitable actuators for corresponding applications.	Application/Analysis (Level-III/Level-IV)
CO4	To model the piezoelectric effect for energy harvesting and demonstrate the measurement and signal processing techniques for structural dynamics testing.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

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

Reference Books		
1.	Title	Smart Materials and Technologies: For the Architecture and Design Professions
	Author	Michelle Addington and Daniel L. Schodek
	Publisher	Routledge
	Edition	2nd Edition

Course Contents		
	UNIT I: 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.	**10**
	UNIT II: Smart Sensors and Technologies - Smart Sensors: Accelerometers - Force Sensors- Load Cells, Torque Sensors, Pressure Sensors, Microphones, Impact Hammers- MEMS Sensors – Fiber Optic Sensors.	**8**
	UNIT III: Smart Actuator and its Techniques – Role of Actuators and Actuator materials – Piezoelectric and Electrostrictive Materials – Magneto-	**6**

	structural Materials – Shape Memory Alloys – Electro rheological fluids – Electromagnetic actuation.	
	UNIT IV: 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.	**12**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4758	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Electric Vehicle Control Systems (ME 4758)		
Course Objectives	• To design and analyze the architecture and components of electric vehicle control systems. • To apply control strategies for powertrain, braking, and energy recovery in EVs. • To analyze the functioning of motor controllers and battery management systems (BMS). • To evaluate system-level control for safety, performance, and efficiency in electric vehicles.		

Course Outcomes		**Cognitive Levels**
CO1	To gain a comprehensive understanding of the components and control principles of electric vehicles.	Analysis/Comprehension (Level III/Level-II)
CO2	To control various types of electric motors used in EVs, including the use of advanced control techniques.	Knowledge/Analysis (Level-II/Level-IV)
CO3	To design and implement battery management systems, ensuring safety and efficiency.	Application/Analysis (Level-III/Level-IV)
CO4	To integrate advanced control systems in EVs including vehicle dynamics, autonomous driving, and energy management.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VII**	**ODD**

Syllabus of Open Elective-I Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				
Text Books					
1.	Title	Fundamentals of Hybrid and Electric Vehicles			
	Author	K.C.Jain, Amit R.Patil, Arvind J. Bhosale, S.S. Raghuvanshi			
	Publisher	Khanna Publishers			
	Edition	1st Edition			
Reference Books					
1.	Title	Electric Motors and Drives: Fundamentals, Types and Applications			
	Author	Austin Hughes, Bill Drury			
	Publisher	Newnes			
	Edition	4th Edition			
Course Contents	**UNIT I**: 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				**9**
	UNIT II: 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.				**9**
	UNIT III: 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				**9**
	UNIT IV: 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.				**9**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%				

Syllabus of Open Elective-II Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 4850	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Energy Storage Technologies (ME 4850)		
Course Objectives	• To introduce students to the need for energy storage technologies and their role in modern energy systems. • To provide an understanding of various energy storage methods including thermal, chemical, electromagnetic, and electrochemical systems. • To explain the working principles, advantages, limitations, and applications of key storage technologies such as batteries, supercapacitors, and fuel cells. • To explore the design considerations and challenges associated with energy storage in electric vehicles and smart grids. • To evaluate the performance, economic viability, and future potential of emerging energy storage technologies.		

Course Outcomes		**Cognitive Levels**
CO1	Describe the importance, classification, and application areas of different energy storage technologies.	Analysis/Comprehension (Level IV/Level-II)
CO2	Analyze and compare thermal and chemical storage systems in terms of efficiency, materials used, and applications.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Explain the operating principles and characteristics of batteries, supercapacitors, and fuel cells.	Application/Analysis (Level-III/Level-IV)
CO4	Design basic battery systems for electric vehicles considering thermal management, safety, and lifecycle parameters.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Assess the feasibility and performance of storage systems for integration into power and transportation sectors.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**	**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	Engineering Mathematics-II (MA 1201)				

Text Books		
1.	Title	Energy Storage: A New Approach
	Author	Ralph Zito

	Publisher	Wiley	
	Edition	1st Edition (2010)	
2.	Title	Energy Storage	
	Author	Robert A. Huggins	
	Publisher	Springer Science & Business Media	
	Edition	1st Edition (2010)	
Reference Books			
1.	Title	Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost	
	Author	Gianfranco Pistoia and Boryann Liaw	
	Publisher	Springer International Publishing	
	Edition	1st Edition (2018)	
Course Contents	**UNIT I:** 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.		**6**
	UNIT II: 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.		**6**
	UNIT III: Chemical storage systems – Hydrogen, methane; chemical storage of solar energy; applications, advantages and limitations, challenges and future prospects.		**6**
	UNIT IV: Electromagnetic storage systems – Double-layer capacitors, superconducting magnetic energy storage (SMES), concepts, advantages, limitations, and future prospects.		**6**
	UNIT V: 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.		**6**
	UNIT VI: Battery design for transportation – Mechanical design and packaging of battery packs, quick chargers, optimization methods, thermal runaway, battery thermal management, battery recycling.		**6**
Course Assessment	Total Marks =100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Syllabus of Open Elective-II Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

<table>
<tr><td rowspan="2">Course Code:
ME 4851</td><td>Open Elective Course: (Y/N)</td><td>Departmental Core Course: (Y/N)</td><td>Departmental Elective Course: (Y/N)</td></tr>
<tr><td>Y</td><td>N</td><td>N</td></tr>
<tr><td colspan="2">Type of Course</td><td colspan="2">Theory Course</td></tr>
<tr><td colspan="2">Course Title & Code</td><td colspan="2">Total Quality Management (ME 4851)</td></tr>
<tr><td colspan="2">Course Objectives</td><td colspan="2">• To equip students with the knowledge and skills to implement and improve quality systems within organizations.
• To foster understanding of TQM philosophies, quality models, and improvement tools, enabling participants to enhance customer satisfaction and improve processes.
• To cultivate a culture of continuous improvement and customer focus throughout the organization.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="2">Cognitive Levels</td></tr>
<tr><td>CO1</td><td colspan="2">Understand the fundamentals of quality management practices.</td><td>Knowledge/Comprehension (Level I/Level-II)</td></tr>
<tr><td>CO2</td><td colspan="2">Understand quality management philosophies, techniques, and frameworks</td><td>Knowledge/Analysis (Level-I/Level-IV)</td></tr>
<tr><td>CO3</td><td colspan="2">Discuss the need of customer expectations, employee involvement and supplier partnership.</td><td>Comprehension/Synthesis (Level-II/Level-V)</td></tr>
<tr><td>CO4</td><td colspan="2">Adopt TQM methodologies for continuous quality improvement</td><td>Synthesis/Evaluation (Level-V/Level-VI)</td></tr>
<tr><td>CO5</td><td colspan="2">Identify the areas of improvement through measurement of cost of poor quality, effectiveness and efficiency of processes</td><td>Comprehension/Synthesis (Level-II/Level-V)</td></tr>
<tr><td>CO6</td><td colspan="2">Apply the TQM tools and techniques to improve the product and process quality.</td><td>Application/Analysis (Level-III/Level-IV)</td></tr>
<tr><td>CO7</td><td colspan="2">Describe quality Management system standards and certification process.</td><td>Comprehension/Synthesis (Level-II/Level-V)</td></tr>
<tr><td>CO8</td><td colspan="2">Apply TQM process and concepts to enhance the performance of systems</td><td>Application/Analysis (Level-III/Level-IV)</td></tr>
<tr><td colspan="2">Semester</td><td colspan="2">VIII</td><td>EVEN</td></tr>
<tr><td colspan="2" rowspan="2">Contact Hours</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Credits</td><td>Total Teaching Hours</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>36</td></tr>
<tr><td colspan="2">Prerequisite course codes with course names</td><td colspan="5">NA</td></tr>
<tr><td colspan="7">Text Books</td></tr>
</table>

Syllabus of Open Elective-II Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

1.	Title	Total Quality Management	
	Author	Dale H.Besterfiled	
	Publisher	Pearson Education, Delhi, 2015	
	Edition	4th Edition	
2.	Title	Total Quality Management	
	Author	Subburaj Ramasamy	
	Publisher	Tata McGraw Hill Ltd., 2005	
	Edition	1st Edition	
3.	Title	Quality Management - Concepts and Tasks	
	Author	Narayana V and Sreenivasan N.S.	
	Publisher	New Age International, Delhi, 1996.	
	Edition	1st Edition	
Reference Books			
1.	Title	Fundamental of Quality Control and Improvement	
	Author	Mitra A	
	Publisher	PHI, 2008	
	Edition	3rd Edition	
2.	Title	Quality Planning and Analysis	
	Author	Juran J M and Gryna F M	
	Publisher	Tata McGraw Hill, 2001	
	Edition	4th Edition	
3.	Title	Quality Control and Total Quality Management	
	Author	Jain	
	Publisher	Khanna Publications, New Delhi, 2001	
	Edition	1st Edition	
Course Contents	**UNIT I**: 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.		**10**
	UNIT II: 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.		**8**
	UNIT III: TQM Tools: Benchmarking, Quality Function Deployment (QFD) - House of Quality, Taguchi Robust Design Concept, Total		**8**

	Productive Maintenance (TPM), FMEA, The seven tools of quality, Process capability, Concept of six sigma, New seven management tools, Case studies.	
	UNIT IV: 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.	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4852	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N

Type of Course	Theory Course
Course Title & Code	Computer Aided Geometric Design (ME 4852)
Course Objectives	• To understand the basics to curves, surfaces and solid representations • To develop algorithms and codes for the curves, surfaces and solids

Course Outcomes		**Cognitive Levels**
CO1	To introduce the basic terminologies and the mathematical definitions	Analysis/Comprehension (Level IV/Level-II)
CO2	To be able to understand Bezier and Spline curves and its formulations	Knowledge/Analysis (Level-I/Level-IV)
CO3	To be able to understand surface representations and its formulations	Application/Analysis (Level-III/Level-IV)
CO4	To be able to understand solid representations and its formulations	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books

1.	Title	Geometric Modeling
	Author	Michael E. Mortenson
	Publisher	John Wiley & Sons

	Edition	2nd Edition, 1997	
2.	Title	Mathematical Elements for Computer Graphics	
	Author	David Rogers and J. Alan Adams	
	Publisher	McGraw Hill Education	
	Edition	2nd Edition, 2017	
Reference Books			
1.	Title	Curves and Surfaces for CAGD: A Practical Guide	
	Author	Gerald Farin	
	Publisher	Morgan Kaufmann Publishers	
	Edition	5th Edition, 2001	
Course Contents	**UNIT I**: **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).		**8**
	UNIT II: Curves 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.		**10**
	UNIT III: Surfaces 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		**10**
	UNIT IV: Solid modeling 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)		**8**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Syllabus of Open Elective-II Courses

Department of Mechanical Engineering, National Institute of Technology Manipur

Course Code: ME 4853	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Introduction to Micro Electro Mechanical Systems (ME 4853)		
Course Objectives	• To impart knowledge of MEMS and its engineering applications • To understand the various aspects like fabrication, design and packaging in MEMS		

Course Outcomes		**Cognitive Levels**
CO1	To get familiarize with MEMS and its engineering application	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand the working principle and mechanisms in MEMS devices	Knowledge/Analysis (Level-I/Level-IV)
CO3	To understand the various fabrication processes involved	Application/Analysis (Level-III/Level-IV)
CO4	To understand the various design aspects of MEMS and its packaging	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**	**EVEN**

Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36

Prerequisite course codes with course names	NA

Text Books		
1.	Title	MEMS & Microsystems Design and Manufacturing
	Author	Tai–Ran Hsu
	Publisher	John Wiley & Sons
	Edition	2nd Edition, 2008

Reference Books		
1.	Title	The MEMS Handbook
	Author	Mohamed Gad-el-Hak
	Publisher	CRC Press
	Edition	2nd Edition, 2017
2.	Title	Fundamentals of Microfabrication
	Author	Marc J. Madou
	Publisher	CRC Press
	Edition	2nd Edition, 2018

Course	**UNIT I**: **Introduction**	**7**

Contents	Definition of MEMS. MEMS devices. Silicon as a MEMS material – mechanical properties of silicon. Mechanical components in MEMS. Design concepts of mechanical components.	
	UNIT II 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.	**9**
	UNIT III 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.	**10**
	UNIT IV Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly – Selection of Packaging Materials.	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4854	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Supply Chain Management (ME 4854)		
Course Objectives	• To understand the concept of Supply chain management and apply this knowledge to understand the working of the corporate world. • To optimize processes and ensure seamless coordination among various stakeholders involved in the Supply Chain. • To create a competitive advantage for the organization by delivering value to customers. At the same time, it is also about maximizing efficiency and minimizing costs. • To give a highlight on Emerging Trends and Innovations in Supply Chain Management, Digital transformation and technology in supply chains, Role of IoT, etc.		

Course Outcomes		**Cognitive Levels**
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	Analysis/Comprehension (Level IV/Level-II)

	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.	Knowledge/Analysis (Level-I/Level-IV)
CO3	Understand drivers of supply chain performance, Analyse factors influencing network design and forecasting in a supply chain.	Application/Analysis (Level-III/Level-IV)
CO4	Understand the role of aggregate planning, inventory, IT and coordination in a supply chain.	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Supply Chain Management - Strategy, Planning and Operation
	Author	Sunil Chopra and Peter Meindl
	Publisher	Pearson Education Asia, 2021
	Edition	7th Edition
2.	Title	Designing and Managing the Supply Chain - Concepts Strategies and Case Studies
	Author	David Simchi-Levi, Philp Kamintry and Edith Simchy Levy
	Publisher	Tata-McGraw Hill, 2007
	Edition	3rd Edition.
Reference Books		
1.	Title	Managing Supply Chains: A Logistics Approach
	Author	John J Coyle
	Publisher	Cengage Learning, 2019
	Edition	10th Edition
2.	Title	Modelling the Supply Chain

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Department of Mechanical Engineering, National Institute of Technology Manipur

	Author	Jeremy F Shapiro	
	Publisher	Cengage Learning, 2019	
	Edition	3rd Edition	
Course Contents	**UNIT I**: 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.		**8**
	UNIT II: 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.		**10**
	UNIT III: 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.		**8**
	UNIT IV: 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		**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		

Course Code: ME 4855	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Introduction to Design Thinking (ME 4855)		
Course Objectives	• To expose the student with state of the art perspectives, ideas, concepts, and solutions related to the design and execution of projects using design thinking principles. • To prepare the mindset and discipline of systemic inspiration driven by a desire to identify new sources of ideas, and new models especially outside their regular working atmosphere. • To propose a concrete, feasible, viable and relevant innovation project/challenge.		
Course Outcomes			**Cognitive Levels**

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CO1	Interpret the relationship between R&D and innovation Strategies	Analysis/Comprehension (Level IV/Level-II)
CO2	Formulate pathways for New Product Development	Knowledge/Analysis (Level-I/Level-IV)
CO3	Understand the different strategic alliances and firm's intellectual property rights.	Application/Analysis (Level-III/Level-IV)
CO4	Understand the types and models of innovation and the frameworks of innovation	Synthesis/Evaluation (Level-V/Level-VI)

Semester	**VIII**		**EVEN**		
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School
	Author	Idris Mootee
	Publisher	John Wiley & Sons
	Edition	1st Edition
2.	Title	Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation
	Author	Tim Brown
	Publisher	HarperCollins Publishers Ltd
	Edition	1st Edition
Reference Books		
1.	Title	Solving Problems with Design Thinking
	Author	Jeanne Liedtka, Andrew King, and Kevin Bennett
	Publisher	Columbia Business School Publishing
	Edition	1st Edition, 2013
2.	Title	Design Thinking : Understand – Improve – Apply
	Author	Christoph Meinel, Larry Leifer and Hasso Plattner
	Publisher	Springer Berlin, Heidelberg
	Edition	1st Edition, 2013

Course Contents	**UNIT I**: 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.	**8**

	UNIT II: 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.	**8**
	UNIT III: 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.	**10**
	UNIT IV: 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.	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4856	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Industry 4.0 (ME 4856)		
Course Objectives	• To learn about the essential goal of Industry 4.0 • To make manufacturing and related industries such as logistics faster, more efficient, and more customer-centric, while at the same time going beyond automation and optimization, and detect new business opportunities and models • To introduce the basics of Industry 4.0 and Sustainability Assessment of Manufacturing Industry • To explain the Significance of Learn production system • To apply the concepts of smart factories for industry 4.0		

Course Outcomes		**Cognitive Levels**
CO1	To recognize need and trends of Industry 4.0.	Analysis/Comprehension (Level IV/Level-II)
CO2	To understand concepts and technologies supporting Industry 4.0.	Knowledge/Analysis (Level-I/Level-IV)

CO3	To explore challenges and industrial applications of Industry 4.0.	Application/Analysis (Level-III/Level-IV)
CO4	Understand cyber physical system and the emerging applications.	Synthesis/Evaluation (Level-V/Level-VI)
CO5	Implement the industry 4.0 to solve engineering problems.	Application/Analysis (Level-III/Level-IV)

Semester	**VIII**	**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	The Fourth Industrial Revolution
	Author	Klaus Schwab
	Publisher	Portfolio Penguin, 2016
	Edition	1st Edition
2.	Title	Industry 4.0: The Industrial Internet of Things
	Author	Alasdair Gilchrist
	Publisher	Apress, 2016
	Edition	1st Edition
Reference Books		
1.	Title	Introduction to Six Sigma
	Author	N A Siddiqui
	Publisher	New Age International Private Limited, 2016
	Edition	1st Edition

Course Contents	**UNIT I**: Overview History – Industrial Revolution - Introduction to Industry 4.0 - Profound and Systematic Change – Trends In Industry 4.0	**8**
	UNIT II: Industry 4.0: Sustainability Assessment of Manufacturing Industry Sustainability – Supply Chain Management- Information and Communication Technology- Introduction To Emerging Issues	**8**
	UNIT III: 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.	**10**

	UNIT IV: 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	**10**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%	

Course Code: ME 4857	**Open Elective Course: (Y/N)**	**Departmental Core Course: (Y/N)**	**Departmental Elective Course: (Y/N)**
	Y	N	N
Type of Course	Theory Course		
Course Title & Code	Energy Audit and Energy Management (ME 4857)		
Course Objectives	• To examine the current and future energy scenario at national and global level. • To understand the various methodologies and terminologies used in this field. • To analyse the various types of energy auditing reports. • To explain the different government regulations associated with energy management system.		

Course Outcomes		**Cognitive Levels**
CO1	To gain an understanding of the fundamental principles and strategies of energy management.	Analysis/Comprehension (Level II/Level-IV)
CO2	To conduct various types of energy audits, utilizing appropriate methodologies and instruments.	Knowledge/Analysis (Level-I/Level-IV)
CO3	To identify and implement energy efficiency and conservation measures in buildings and industrial settings.	Application/Analysis (Level-II/Level-III)
CO4	To apply economic and policy aspects to implement sustainable energy practices.	Synthesis/Evaluation (Level-IV/Level-V)

Semester	**VIII**	**EVEN**			
Contact Hours	**Lecture**	**Tutorial**	**Practical**	**Credits**	**Total Teaching Hours**
	3	0	0	3	36
Prerequisite course codes with course names	NA				

Text Books		
1.	Title	Energy Audit and Management
	Author	L. Ashok Kumar, Gokul Ganesan
	Publisher	CRC Press

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	Edition	1st Edition	
Reference Books			
1.	Title	Energy management handbook	
	Author	Stephen A. Roosa, Steve Doty, Wayne C. Turner	
	Publisher	Taylor & Francis	
	Edition	9th Edition	
Course Contents	**UNIT I**: Introduction: Fundamentals of energy management and energy conservation, Energy scenario at national and global level, Energy Management Strategies		**9**
	UNIT II: Energy Efficiency in Thermal and Electrical Utilities: Waste Heat Recovery, Cogeneration, Energy Conservation in Buildings and ECBC, Energy Efficiency Technologies.		**11**
	UNIT III: 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.		**10**
	UNIT IV: Government Policies and Regulations: Laws And Acts of Electricity in India, Regulations, State Governments Policies.		**6**
Course Assessment	Total Marks=100 Continuous Evaluation 20% Mid Semester 30% End Semester 50%		