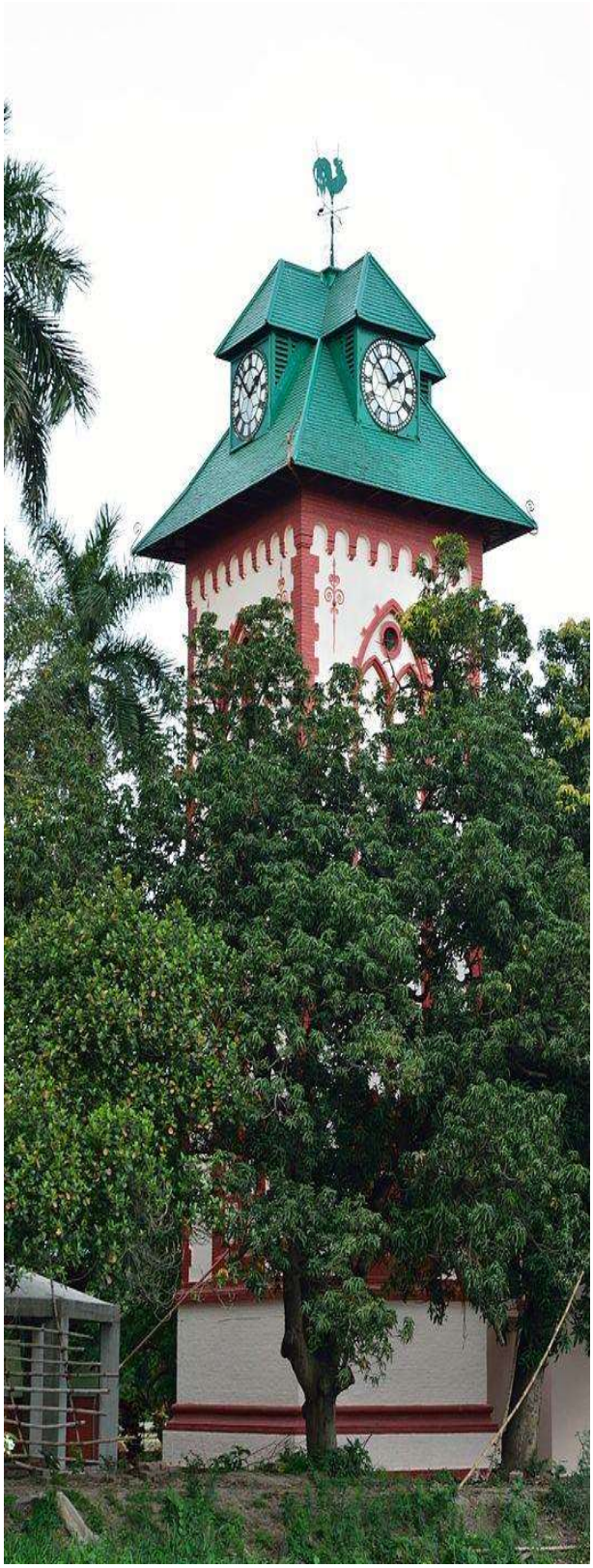

Mechanical Engineering
(for Group B)

B.Tech. Program

Course Structure and Syllabus

(Effective from 2025-26 admitting batch onwards)

Indian Institute of Engineering Science and Technology (IIEST), Shibpur

Botanic Garden, Howrah

Contents

Course Structure

First Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	BSC	Engineering Mathematics – I		3	1	0	4	4	100
2	BSC	Engineering Physics		3	0	0	3	3	100
3	ESC	Introduction to AI and ML		3	0	0	3	3	100
4	ESC	Engineering Mechanics		3	0	0	3	3	100
5	ESC	Basic Electrical Engineering (EE)		3	0	0	3	3	100
6	VAC	Energy, Environment and Climate Change		2	0	0	2	2	50
Theory Sub-total				**17**	**1**	**0**	**18**	**18**	**550**
7	ESC	Engineering Graphics		0	0	3	2	3	50
8	ESC	Basic Electrical Engineering Lab (EE)		0	0	3	2	3	50
9	BSC	Engineering Physics		0	0	3	2	3	50
10		NSS/NCC/PT/Yoga					R*		
Practical Sub-total				**0**	**0**	**9**	**6**	**9**	**150**
First Semester Total				**17**	**1**	**9**	**24**	**27**	**700**

*R: Required (Non-credit but with grade)

Second Semester

Sl. No	Type	Course Name	Course code	Class Load/Week			Credit	Class load/ Week	Marks
				L	T	P			
1	BSC	Engineering Mathematics – II		3	1	0	4	4	100
2	BSC	Engineering Chemistry		3	0	0	3	3	100
3	ESC	Basic Electronics Engineering (ETC)		3	0	0	3	3	100
4	VAC	Well-being and happiness		2	0	0	2	2	50
5	HSC	Professional communication in English		2	1	0	3	3	100
6	PC	Thermodynamics	ME1201N	3	0	0	3	3	100
Theory Sub-total				**16**	**2**	**0**	**18**	**18**	**550**
7	ESC	Workshop		0	0	3	2	3	50
8	ESC	Computer programming practice		0	0	3	2	3	50
9	ESC	Machine Drawing (AE&AM)		0	0	3	2	3	50
10	PC	Thermodynamics Lab	ME1271N	0	0	3	2	3	50
11		NSS/NCC/PT/Yoga					R*		
Practical Sub-total				**0**	**0**	**12**	**8**	**12**	**200**
Second Semester Total				**16**	**2**	**12**	**26**	**30**	**750**

*R: Required (Non-credit but with grade)

Third Semester

Sl. No.	Type	Course Name	Course	Class Load/Week			Credit	Class load	Marks
				L	T	P			
1	ESC	Fluid Mechanics		3	0	0	3	3	100
2	ESC	Strength of Materials		3	0	0	3	3	100
3	ESC	Dynamics of Rigid Bodies		3	0	0	3	3	100
4	PC	Applied Thermodynamics	ME2101N	3	0	0	3	3	100
5	PC	Engineering Materials & Processes	ME2102N	3	1	0	4	4	100
Theory Sub-total				**15**	**1**	**0**	**16**	**16**	**500**
6	ESC	Fluid Mechanics Lab		0	0	3	2	3	50
7	ESC	Design of Everyday Things / Learning by doing (AP)		0	0	3	2	3	50
8	ESC	Strength of Materials Laboratory		0	0	3	2	3	50
9	PC	Applied Thermodynamics Lab	ME2171N	0	0	3	2	3	50
Practical Sub-total				**0**	**0**	**12**	**8**	**12**	**200**
Third Semester Total				**15**	**1**	**12**	**24**	**28**	**700**

Fourth Semester

Sl. No	Type	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	ESC	Fluid Power Engineering		3	0	0	3	3	100
2	PC	Fundamentals of Machine Design	ME2201N	3	0	0	3	3	100
3	PC	Mechanisms and Manipulators	ME2202N	3	1	0	4	4	100
4	PC	Machine Tools and Metal Cutting	ME2203N	3	0	0	3	3	100
5	OE	OE1		3	0	0	3	3	100
Theory Sub-total				**15**	**1**	**0**	**16**	**16**	**500**
6	ESC	Fluid Machinery laboratory		0	0	3	2	3	50
9	PC	CAD Modelling & Simulation Lab	ME2271N	0	0	3	2	3	50
7	PC	Measurement Laboratory	ME2273N	0	0	3	2	3	50
8	PC	Numerical Methods in Engg Lab	ME2281N	0	0	3	2	3	50
Practical Sub-total				**0**	**0**	**12**	**8**	**12**	**200**
Fourth Semester Total				**15**	**1**	**12**	**24**	**28**	**700**

Fifth Semester

Sl. No	Type	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	PC	Heat Transfer	ME3101N	3	0	0	3	3	100
4	PC	Design of Power Transmission Elements	ME3102N	3	0	0	3	3	100
2	PC	Dynamics and Vibration of Machines	ME3103N	3	0	0	3	3	100
3	PC	Manufacturing Technology	ME3104N	3	0	0	3	3	100
5	OE	OE2		3	0	0	3	3	100
Theory Sub-total				**15**	**0**	**0**	**15**	**15**	**500**
6	PC	Heat Transfer Laboratory	ME3171N	0	0	3	2	3	50
7	PC	Design of Power Transmission Elements Sessional	ME3272N	0	0	3	2	3	50
8	PC	Metal Cutting Laboratory	ME3174N	0	0	3	2	3	50
Practical Sub-total				**0**	**0**	**9**	**6**	**9**	**150**
Fifth Semester Total				**15**	**0**	**9**	**21**	**24**	**650**

Sixth Semester

Sl. No	Type	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	PC	Steam and Gas Power Systems	ME3201N	3	0	0	3	3	100
2	PC	Design of Frictional Machine Elements	ME3202N	3	1	0	4	4	100
3	PC	Advanced Manufacturing Technology	ME3203N	3	0	0	3	3	100
4	HSC	Finance Economics and Management for Engineers		3	0	0	3	3	100
5	OE	OE3		3	0	0	3	3	100
Theory Sub-total				**15**	**1**	**0**	**16**	**16**	**500**
6	PC	Design of Frictional Machine Elements Sessional	ME3272N	0	0	3	2	3	50
7	PC	Advanced Manufacturing Technology Lab	ME3273N	0	0	3	2	3	50

8	O	Seminar & Group Discussion	ME3274N	0	0	3	2	3	50
Practical Sub-total				**0**	**0**	**9**	**6**	**9**	**150**
Sixth Semester Total				**15**	**1**	**9**	**22**	**25**	**650**

Seventh Semester

Sl. No.	Type	Course Name	Course Code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	PC	Internal Combustion Engines and Jet Propulsion	ME4101N	3	0	0	3	3	100
2	PC	Industrial Engg. & Operation Research	ME4102N	3	0	0	3	3	100
3	VAC	Sociology & Professional Ethics		3	0	0	3	3	100
4	OE	OE4		3	0	0	3	3	100
Theory Sub-total				**12**	**0**	**0**	**12**	**12**	**400**
5	PC	Engine Laboratory	ME4171N	0	0	3	2	3	50
6	PC	Refrigeration & Air Conditioning Lab	ME4172N	0	0	3	2	3	50
7	I	Internship	ME4191N				2		50
Practical Sub-total				**0**	**0**	**6**	**6**	**6**	**150**
Seventh Semester Total				**12**	**0**	**6**	**18**	**18**	**550**

Eighth Semester

Sl. No.	Type	Course Name	Course Code	Class Load/Week			Credit	Class load / week	Marks
				L	T	P			
1	OE	OE5 (from NPTEL, for the students opting Internship / From the enlisted courses from the Institute, for others)		3	0	0	3	3	100
Theory Sub-total				**3**	**0**	**0**	**3**	**3**	**100**
2	I/P	One Semester Internship / Project	ME4291N				8		300
3	O	Grand viva	ME4292N				2		50
Practical Sub-total				**0**	**0**	**0**	**10**	**0**	**350**
Eighth Semester Total				**3**	**0**	**0**	**13**	**3**	**450**

Catalogue of Courses

Catalogue of Engineering Science Courses

Sl. No.	Course Code	Course Name
1	YYXXXXN	Introduction to AI & ML
2		Engineering Mechanics
3		Basic Electrical Engineering
4		Engineering Graphics
5		Basic Electrical Engineering Lab (EE)
6		Basic Electronics Engineering (ETC)
7		Workshop
8		Computer Programming Practices
9		Machine Drawing (AE&AM)
10		Fluid Mechanics
11		Strength of Materials
12		Dynamics of Rigid Bodies
13		Fluid Mechanics Laboratory
14		Design of Everyday Things / Learning by doing (AP)
15		Strength of Materials Laboratory
16		Fluid Power Engineering
17		Fluid Machinery laboratory
18	ME1202N	Fundamentals of Manufacturing
19	ME1272N	Fundamentals of Manufacturing Lab
20	ME1203N	Heat Power Engineering
21	ME1273N	Heat Power Engineering Lab

Catalogue of Basic Science Courses

Sl. No.	Course Code	Course Name
1	ZZXXXXN	Mathematics – I
2		Engineering Physics
3		Engineering Physics Lab
4		Mathematics – II
5		Engineering Chemistry

Catalogue of Humanities and Social Science Courses

Sl. No.	Course Code	Course Name
1	UUXXXXN	Professional communication in English
2		Finance Economics and Management for Engineers

Catalogue of Value Added Courses

Sl. No.	Course Code	Course Name
1	VVXXXXN	Energy, Environment and Climate Change
2		Well-being and happiness
3		Sociology & Professional Ethics

Catalogue of Program Core Courses

Sl. No.	Course Code	Course Name
1	ME1201N	Thermodynamics
2	ME1271N	Thermodynamics Lab
3	ME2101N	Applied Thermal Engineering
4	ME2102N	Engineering Materials & Processes
5	ME2171N	Applied Thermal Engineering Lab
6	ME2201N	Fundamentals of Machine Design
7	ME2202N	Mechanisms and Manipulators
8	ME2203N	Machine Tools and Metal Cutting
9	ME2271N	CAD Modelling & Simulation Lab
10	ME2272N	Measurement Laboratory
11	ME2281N	Numerical Methods in Engg Lab
12	ME3101N	Heat Transfer
13	ME3102N	Design of Power Transmission Elements
14	ME3103N	Dynamics and Vibration of Machines
15	ME3104N	Manufacturing Technology
16	ME3171N	Heat Transfer Laboratory
17	ME3172N	Design of Power Transmission Elements Sessional
18	ME3174N	Metal Cutting Laboratory
19	ME3201N	Steam and Gas Power Systems
20	ME3202N	Design of Frictional Machine Elements

21	ME3203N	Advanced Manufacturing Technology
22	ME3272N	Design of Frictional Machine Elements Sessional
23	ME3273N	Advanced Manufacturing Technology Lab
24	ME4101N	Internal Combustion Engines and Jet Propulsion
25	ME4102N	Industrial Engg. & Operation Research
26	ME4171N	Engine Laboratory
27	ME4172N	Refrigeration & Air Conditioning Lab

Catalogue of Program Specific Elective Courses

Sl. No.	Course Code	Course Name
		NIL

Catalogue of Open Elective Courses

Sl. No.	Course Code	Course Name
1	ME2221N	Numerical Methods in Engg.
2	ME3121N	Refrigeration & Air Conditioning
3	ME3122N	Dynamics of Fluid Flow
4	ME3123N	Analytical Mechanics
5	ME3124N	Laser Material Processing
6	ME3125N	Welding Technology & Testing
7	ME3221N	Automobile Engineering
8	ME3222N	Power Plant Engineering
9	ME3223N	Electric Vehicles Technology
10	ME3224N	Introduction to Biomechanics
11	ME3225N	Control Systems Engineering
12	ME3226N	Robotics
13	ME3227N	Manufacturing Automation
14	ME4121N	Energy Storage Technology
15	ME4122N	Solar and Wind Energy
16	ME4123N	CAD/CAM
17	ME4124N	Finite Element Method for Engineering
18	ME4125N	Additive Manufacturing
19	ME4126N	AI & ML Applications in Mechanical Engineering

20	ME4221N	Computational Fluid Dynamics & Heat Transfer
21	ME4222N	Fatigue and Fracture Mechanics
22	ME4223N	Industrial Tribology
23	ME4224N	Project Management

Syllabi of Courses

2nd Semester

Course Code	ME1201N	Course Name	Thermodynamics	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	Mathematics	Co-requisite Courses	Physics	Progressive Courses	Applied Thermal Engineering
Course Offering Department		Mechanical Engineering		Data Book / Codes / Standards	Steam tables

Course Objective	• To understand and apply the fundamental concepts and laws of thermodynamics to energy systems • Use property data and state relations for pure substances and gases • To gather sufficient knowledge about the properties of moist air

Module	Syllabus	Duration (Class-hour)	Module Outcome
1	**Basic concepts**: Thermodynamic system and its properties, Processes and cycles, Quasi-static process, Reversible process, Thermodynamic equilibrium. Zeroth law of thermodynamics, Work and heat interactions, Measurement of pressure and temperature.	3	• Fundamental concept of engineering thermodynamics • Terminologies and definitions
2	**First law of thermodynamics**: Statement, Corollaries and its application to closed and open systems, Steady and unsteady flow processes	4	• Application of first law of thermodynamics to various engineering systems
3	**Second law of thermodynamics:** Concepts of heat reservoir and heat engine, Kelvin-Planck and Clausius statements of second law of thermodynamics, Carnot cycle, Carnot's theorem, Refrigerator and heat pump, Inequality of Clausius.	6	• Concept of heat engine, heat pump will be clear • Carnot principle will be clear • Student will learn why process occurs in a certain direction spontaneously
4	**Entropy:** Principle of increase of entropy, Availability and Irreversibility, Concept of entropy generation and exergy analysis	3	• Concept of entropy • how entropy generation effect thermodynamic processes.
5	**Properties of gas and gas mixture:** Ideal gas, Equation of state, Analysis of different processes undergone by a gas, Dalton's law and Amagat's law, Characteristic gas constant and molecular weight of mixture of perfect gasses, Gibbs-Dalton law and its applications	6	• Student will be able to determine properties of gas and gas mixtures
6	**Maxwell's equations** in thermodynamics; Thermodynamic relations	2	• Student will learn Maxwell's equations which is necessary in advance stages of the course

7	**Reactive mixtures:** Combustion equations, Stoichiometric and actual air-fuel ratios, Lean and rich mixtures, Analysis of actual combustion products.	5	• Student will be able to find how much air required to burn certain amount of fuel • Dew point temperature of combustion product
8	**Properties of pure substance:** Phase equilibrium, Diagram and related properties, Gibbs phase rule, Relevant properties of pure substance, Steam table, Mollier diagram, T-s and p-h diagrams of steam, Dryness fraction of steam and its measurement	6	• Student will learn how to find properties of steam at different states. • Would be able to determine change of properties during a process
9.	**Psychrometry:** Relevant psychrometric properties, Measurement of DBT and WBT of moist air, Sling psychrometer, Psychrometric chart, Psychrometric processes.	5	• Characteristics of moist air, determination of specific and relative humidity • Use of Psychrometric Chart
10.	**Class Test and Viva**	2	
	TOTAL	42	

Course Outcome	The student should be able to Understand the basic terms used to define thermodynamic systems and various processes Distinguish between heat engine and refrigerator/heat pump Apply the Laws of Thermodynamics to calculate enthalpy, entropy and irreversibility Use property tables, psychrometric chart and software such as EES and MATLAB to determine thermodynamic properties of different systems Solve thermodynamic problems with appropriate assumptions Evaluate qualitatively and quantitatively (in some cases) thermodynamic systems for sustainability and environmental impact

Learning Resources	**Text Books:** 1. Engineering Thermodynamics by P. K. Nag 2. Fundamentals of Thermodynamics by Sonntag, Borgnakke and Van Wylen **Reference Books:** 1. Engineering Thermodynamics: Work and Heat Transfer by Rogers and Mayhew 2. Principles of Engineering Thermodynamics by Moran and Shapiro

2nd Semester

Course Code	ME1202N	Course Name	Fundamentals of Manufacturing	Course Category	ESC	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	To impart knowledge on different manufacturing methods to all engineering students. This course will give an overview of almost all types of manufacturing processes and their typical products. This will also give an exposure to force / energy requirement for some of the processes.

Module	Syllabus	Duration (class-hour)	Module outcome
Basic concepts of different manufacturing processes	Basic concepts of different manufacturing processes: casting, machining, forming joining process; their applications; Basics of additive manufacturing process: the steps of the process in general and some application to be discussed only.	08	Understanding on the various existing manufacturing processes, concepts and application
Casting	Steps of mould-making taking example of a particular product; different parts of a mould sprue, runner, riser and gating system; pattern and core, with specific example (eg., a valve body) how intricate shape is manufactured. Some modern casting methods and their applications: centrifugal casting and investment casting; Calculation for casting : total heat required for mass production of a particular product.	08	Basic knowledge for making mould, various components of a mould, gating system design, various casting processes and numerical problems
Machining	Different types of machine and their specific applications (different shapes): Lathe, Milling, Drilling, Shaping; Calculation of machining time; Lathe specification and different cutting tools; Non-conventional machining: EDM and Laser machining: basics only.	08	An overview of the different machining processes, understand about the applications of various machine tools
Metal forming	Classification based on temperature: hot, warm and cold working; bulk deformation and sheet-metal work: examples and applications; Some details of rolling, forging, punching and blanking; Force calculation in forging and punching.	08	Understanding on the various metal forming processes and their applications
Joining processes	Types and terminology of different welding methods , brazing and soldering, their specific applications; Calculation of energy requirement and metal deposition rate of fusion welding; Brief outline of GMAW (MIG) , GTAW (TIG) and Laser welding.	08	Understanding on the basic concept of various welding processes and their applications
	TOTAL	**40**	

Course Outcome	Students will have specific knowledge of product manufacturing as per the service requirements. They will have the in depth knowledge why so many manufacturing processes, starting from the age old casting process to advanced laser beam machining, are running in the industry. They can perform calculation on force / power estimation and other requirement of a particular process (e.g., Rolling)

Learning Resources	**Text book** 1. Manufacturing processes for engineering materials: by S. Kalpakjian, S.R. Schmid, Pearson Pub. India. **Reference book** 1. Fundamentals of Modern Manufacturing by M.P. Groover, John Wiley & Sons Inc. 2. Manufacturing Science by A. Ghosh & A.K. Mullick, East-West Publication 3. Manufacturing Technology by P.N.Rao, Tata McGraw-Hill Publication 4. Welding Technology by JF Little, Tata McGraw-Hill Publication

3rd Semester

Course Code	ME2101N	Course Name	Applied Thermodynamics	Course Category	PC	L	T	P
						3	1	0

Pre-requisite Courses	*Thermodynamics*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards		Thermodynamic property tables of water, air, and various refrigerants	

Course Objective	The objective of the course is • To provide concept about the analysis of various power generation cycles • To provide necessary knowledge to analyse different refrigeration systems • To know about various devices used in thermal power plants • To acquire in-depth knowledge about boilers and compressors • To provide fundamental knowledge about nuclear power Plant

Module	Syllabus	Duration (class-hour)	Module outcome
1.	Different gas power cycles: Carnot, Otto, Diesel, Dual, Stirling, Ericsson and Brayton cycles, Comparison of Otto, Diesel and Dual cycles	08	• Be able to analyze various gas power cycle pertaining to Engines • Key performance parameters • Problem solving skill
2.	Vapour power cycles: Carnot and Rankine cycles, Effect of steam parameters on cycle performance, Reheat and Regenerative steam power cycles.	08	• Be able to analyze various gas power cycle pertaining to Steam power plant • Key performance parameters • Problem solving skill
3.	Refrigeration cycle: Different methods of refrigeration, Refrigerants. Air cycle refrigeration (Bell-Coleman), Vapour compression refrigeration cycle	07	• Be able to analyze various refrigeration cycles • How COP of the system varies with operating parameters • Problem solving skill
4.	Boiler: Classification of boilers. Fire tube and water tube boilers, High pressure and low pressure boiler,. Description and working of Cochran, Babcock-Wilcox, Stirling, Lamont and Benson boilers. Boiler mounting and accessories. Boiler performance analysis and heat balance of a boiler plant..	08	• Learn about different types of boilers • Component of boilers: Accessories and mountings
5.	Reciprocating compressor: Working principle, FAD, Single stage and multi-stage compression with intercooler, optimum inter-stage pressure, volumetric efficiency and isothermal efficiency of compressor.	07	• Compressor classification • application and performance evaluation of reciprocating compressor • Problem solving on compressor

6.	Introduction to rotary compressors: Roots blower, vane type compressors, screw type compressors, centrifugal and axial compressors.	03	• Rotary compressor application and performance evaluation • Problem solving on compressor
7.	Introduction to nuclear power generation: Fundamentals of nuclear reactions and nuclear reactor, estimation of nuclear fuel required for power generation.	05	• Fundamentals on nuclear power generation • Different types of reactor • Problem solving skill related to Nuclear power generation
	Total	**42**	

Course Outcome	After completion of the course students should • be able to analyze various vapour power and gas power cycles • acquire extensive knowledge on boiler and boiler accessories. • be able to solve problems on compressors, • acquire sufficient knowledge for the analysis of refrigeration systems • develop fundamental concept on nuclear power plant

Learning Resources	**Text Books:** 1. Engineering Thermodynamics by P. K. Nag 2. Thermodynamics: An Engineering Approach by Michael A Boles and Yungus A Cengel 3. Principles of Engineering Thermodynamics by Moran and Shapiro **Reference Books:** 1. Principles of Energy Conversion by A. W. Culp 2. Applied Thermodynamics for Engineering Technologists by T. D. Eastop and A. McConkey 3. Refrigeration and Air Conditioning by R C Arora

3rd Semester

Course Code	ME2102N	Course Name	*Engineering Materials and Processes*	Course Category	PC	L	T	P
						3	1	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Material science*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*			Data Book / Codes/Standards	*Nil*

Course Objective	To impart knowledge on different engineering materials, their mechanical properties, heat treatment and manufacturing processes. It also elaborates on phase diagrams mainly of iron-carbon phases and associated heat treatment techniques. It will give in-depth knowledge on the manufacturing processes, namely, casting, metal forming and joining : related terminology, types and power estimation

Module	Syllabus	Duration (class-hour)	Module Outcome
Mechanical properties and their testing	Engineering and true stress-strain diagram, ductile and brittle fracture, hardness, toughness, endurance limit and fatigue testing, creep.	07	Explain mechanical, thermal, electrical and magnetic properties of material and implement the concept in mechanical components design.
Phase diagrams	Solid solutions, binary alloy system, lever rule, Iron-carbon equilibrium diagram, TTT diagrams.	07	Identify different types of defects in the material structure and construct the phase diagram of a multi-phase system of alloy. Analyze the Iron –Iron Carbide equilibrium diagram and discuss the composition, properties and applications of ferrous and nonferrous alloy
Heat treatment	Annealing, normalizing, tempering, and hardening (case hardening and surface hardening).	08	Explain different heat treatment processes for ferrous material.
Engineering materials	A brief overview on metals, alloyed steel, cast iron, nonferrous alloy, ceramics, polymers and composite materials.	06	Classify different materials like metals, polymers, ceramics, composites and advanced materials and analyze different crystal structure of materials
Casting	Types of patterns and allowances; Mould materials and their properties; Solidification; Gating and Risering; Special casting processes: Investment casting, Die casting, Centrifugal casting, Continuous casting; Casting defects.	10	Understanding on the different moulding parameters, casting processes and gating system design
Joining process	Terminology and types; DC and AC welding; Arc length & power calculation; Edge preparation; Shielded Metal Arc welding and Resistance welding; Welding defects and detection methods. Brazing, soldering and adhesive bonding	09	Basic understanding of the different welding parameters, processes, numerical problems
Metal forming processes	Terminology and classification; Fundamentals of hot and cold working	09	Fundamental knowledge on different metal forming

	processes; Load estimation for bulk deformation (forging, rolling, extrusion, drawing); Metal forming defects.		processes used in a manufacturing industry with applications, numerical analysis
	TOTAL	**56**	

Course Outcome	This is one of vital course for mechanical engineering students as this covers a wide range of engineering materials and their processing techniques. This course will help the student for appearing GATE, interview and for their future role in industry. Students will specifically understand why a particular heat treatment is necessary for a product. For the different manufacturing processes, not only the type and terminology of a particular process, also they will be able to learn the power/force requirement for the same.

Learning Resources	**Text book** 1. Manufacturing processes for engineering materials: by S. Kalpakjian, S.R. Schmid, Pearson Pub. India. **Reference book** 1. Fundamentals of Modern Manufacturing by M.P. Groover, John Wiley & Sons Inc. 2. Manufacturing Science by A. Ghosh & A.K. Mullick, East-West Publication 3. Manufacturing Technology by P.N.Rao, Tata McGraw-Hill Publication 4. Welding Technology by JF Little, Tata McGraw-Hill Publication

3rd Semester

Course Code	ME2103N	Course Name	Heat Power Engineering	Course Category	ESC	L	T	P
						3	0	0

Pre-requisite Courses	Engg. Physics, Engg. Mathematics	Co-requisite Courses	Heat Power Lab	Progressive Courses	Power plant Engg., Electric power generation system, Smart grid and Distributed Energy system
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Steam Table with Mollier Diagram, Refrigeration Tables and PsychrometricCharts		

Course Objectives	This course aims to provide a fundamental understanding of thermodynamics and its application to closed and open systems. It covers the behavior of ideal and real gases, analysis of power and refrigeration cycles, psychrometrics and basic heat transfer. Students will also learn the principles of IC engines, air compressors and steam power plants including modifications to the Rankine cycle.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	Introduction to thermodynamics and heat power. Need and objective of the course.	01	❖ Understand the importance and scope of heat power in engineering. ❖ Recognize the relevance of thermal sciences for electrical engineering applications.
II	Thermodynamics: Thermodynamic system, surroundings, properties; processes and cycles; thermodynamic equilibrium, heat and work, internal energy, enthalpy, 1st and 2nd laws of thermodynamics, applications to open and closed systems.	06	❖ Define and differentiate thermodynamic systems, properties and processes. ❖ Apply the first law and second law of thermodynamics to both closed and open systems.
III	Ideal and real gases: Equation of state, non-reactive gas mixtures, properties of pure substance (steam), steam tables and charts, air-water vapour mixture and psychrometry.	05	❖ Analyze the properties and behavior of ideal and real gases and use steam tables and Mollier charts to evaluate steam properties. ❖ Apply psychrometric concepts to analyze air-vapor mixtures.
IV	Power Cycles: Carnot, Otto, Diesel, Dual, Brayton, and Rankine.	06	❖ Understand the working principles of different power cycles. ❖ Evaluate thermal efficiency and performance of each cycle.
V	Refrigeration Cycles: Air and Vapour Refrigeration Cycles.	04	❖ Describe the fundamentals of air and vapor compression refrigeration cycles. ❖ Calculate performance parameters such as the coefficient of performance (COP).
VI	Heat Transfer: Conduction, Convection and Radiation.	02	❖ Understand basic modes of heat transfer: conduction, convection, and radiation. ❖ Apply simple heat transfer concepts in practical thermal systems.

VII	Air Compressors: Reciprocating, Centrifugal and Axial flow compressors.	05	❖ Explain the construction and operation of reciprocating and rotary compressors. ❖ Analyze work done and efficiency of multistage compression with intercooling.
VIII	I.C.Engines: Principles of SI and CI engines, Four-stroke and two-stroke engines, ideal and actual indicator diagrams, mean effective pressure, power and efficiency.	05	❖ Explain the working of two and four stroke SI and CI engines ❖ Interpret indicator diagrams to compute the engine performance.
IX	Steam Power Plant: Modified Rankine cycle, superheat, reheat, regenerationand feed water heaters, Boilers, nozzles and turbines, condenser, cooling tower, deaerator.	06	❖ Describe the layout and working of modern steam power plants and also explain the function of key components like boilers, turbines, condensers, and cooling towers. ❖ Analyze modified Rankine cycles with superheating, reheating, and regeneration for efficiency improvement.
	Total	**40**	

Course Outcome	From this course, students will gain a fundamental understanding of thermodynamics and learn to apply its laws to analyze both closed and open systems. They will be able to evaluate the behavior of ideal and real gases, interpret psychrometric charts, and analyze power and refrigeration cycles for performance assessment. Additionally, students will understand basic heat transfer concepts, the operation of IC engines and compressors, and the components and functioning of steam power plants, including improvements to the Rankine cycle.

Learning Resources	**Text books:** 1. Engineering Thermodynamics by P.K.Nag. 2. Thermal Engineering by P.L.Ballaney. 3. I. C.Engines by V. Ganesan 4. Thermal Engineering by R. K. Rajput **Reference Book:** 1. Applied Thermodynamics for Engineers by Eastop&McConky 2. Power Plant Technology by M. El Wakil

4th Semester

Course Code	ME2201N	Course Name	Fundamentals of Machine Design	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*Strength of Materials*	Co-requisite Courses	*Engineering Mechanics*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards	*Machine Design Data Book by V.B. Bhandari, 2nd Edition, 2019, Chennai McGraw Hill Education*		

Module	Syllabus	Duration (class-hour)	Module Outcome
Introduction	Introduction to mechanical design: Basic steps	02	Know the basic steps of design
Standardization	Standardization (BIS) and preferred numbers	02	understand the design standards
Limits, fits and tolerances	Limits, fits and tolerances	04	Understand the interchangeability of parts.
Stress concentration	Stress concentration and factor of safety	03	Know the material selection, stress concentration
Stress Analysis	Stress at a point, State of stress and strain at a point in 3-dimensions, rectangular stress and strain components, sign conventions, Cauchy's equation, Normal and shear stress on any arbitrary plane	04	Understand the State of stress and strain and concept of Normal and shear stress
Stress invariants, principal stresses	Stress invariants, principal stresses in 3-dimensions and their directions, hydrostatic and deviatoric states of stress, expressions of strain energy, distortion energy in terms of principal stresses, Boundedness of stress components at a point: Mohr's circles in 3D.	06	gain knowledge of stress invariant, failure modes and various failure theories
Theories of failure	Theories of failure in terms of 3-dimensional state of stress for ductile and brittle materials: Maximum principal stress, maximum shear stress, maximum principal strain, total strain energy, distortion energy theories of failure; Introduction of Mohr's theory, i.e., Coulomb Mohr theory and modified Mohr theory for brittle materials	05	Gain the knowledge on maximum shear stress theory, maximum normal stress theory, distortion energy theory, Mohr's theory, Modified Mohr's theory
Variable loads	Theories of failures under variable loading: Concepts of variable loading and fatigue failure, endurance limit- Gerber, Goodman and Soderberg criteria for individual and combined loading, Modified Goodman Diagram Diagram, Application on bolted joints for pressure vessel.	06	Know the Design subjected to variable loads, analyze the fatigue loading.

Design of cotter joint	Cotter joints and its purpose, Different parts, derivation of condition of self-locking of the cotter, materials of cotter joint, Design and calculation of a spigot and socket type cotter joint dimensions based on possible modes of failure, Problem	04	Understand the cotter joints used for shaft connection considering various failure modes
Design of leaf spring	Design of leaf spring: Concepts of uniform beam and beam of uniform strength, Construction of leaf or laminated springs, Nipping, Laminated spring materials, Maximum stress and deflections, Design of important dimensions of a leaf spring with and without nipping, Problems.	04	Gain the knowledge on leaf springs with understanding of uniform beam and beam of uniform strength
	Total	**40**	

Course Outcome	At the end of the course, students should be able to 1. Understand the design standards, limit, fits, tolerances and interchangeability of parts, principles of material selection, stress concentration. 2. Gain knowledge of stress invariant, failure modes and various failure theories (e.g., maximum shear stress theory, maximum normal stress theory, distortion energy theory, Mohr's theory, Modified Mohr's theory). 3. Design machine elements subjected to variable loads, analyze the fatigue loading problems. 4. Design cotter joints considering various failure modes. 5. Design leaf springs with understanding of uniform beam and beam of uniform strength.

Learning Resources	**Text Book** 1. Advanced Mechanics of Solids, by L.S. Srinath, 3rd edition, McGraw Hill Education. 2. Mechanical Engineering Design (6th International Edition), by J.E. Shigley and C.R. Mischke, McGraw-Hill Publications, 2001 3. Machine Design: An Integrated Approach (3rd Edition), by Robert L. Norton, Prentice Hall, 2006. 4. Machine Design Data Book, by V.B. Bhandari, McGraw Hill Education (India) Private limited, 2014. **Reference Books** 1. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980. 2. Engineering Design (3rd International Edition), by George E. Dieter, McGraw-Hill International Book Company, 2000. 3. Introduction to Solid Mechanics (2nd Edition), by I.H. Shames, Prentice-Hall of India Pvt. Ltd., 1990. 4. Mechanical Behavior of Materials (4th Edition), by Norman E. Dowling, Pearson Education Limited, 2013.

4th Semester

Course Code	ME2202N	Course Name	Mechanisms and Manipulators	Course Category	PC	L	T	P
						3	1	0

Pre-requisite Courses	*Math-I & II, Engineering Mechanics, Rigid Body Dynamics*	Co-requisite Courses	*Nil*	Progressive Courses	Machine Design, Dynamics and Vibration of Machine, Robotics, Analytical Mechanics, Control System Engineering
Course Offering Department	*Mechanical Engineering*			**Data Book / Codes/Standards**	*Nil*

Course Objective	The goals of the course are 1. to provide students with comprehensive understanding of Mechanisms, Kinematic pairs, Kinematic Chain, Degrees of Freedom (DOF), Robotic Manipulators 2. to provide techniques to do kinematic analysis of different mechanisms 3. to provide techniques to do dimensional synthesis of different mechanisms 4. to make students aware of different aspects and usefulness of higher pairs (cam and gear) 5. to enable students to perform detailed kinematic analysis and synthesis of cam and gear 6. to give basic idea about open chain and robotic manipulator 7. to equip the students with techniques to do kinematic analysis of robotic manipulators

Module	Syllabus	Duration (class-hour)	Module Outcome
Fundamental concepts of mechanisms	Introduction-Definitions, Classifications, Machine Vs. Mechanism, Kinematic pairs, Kinematic chains, Mobility of mechanisms (Kutzbach and Grubler Criterion), Kinematic inversions, Number synthesis, Rotatability criterion of four bar mechanisms (Grashof's Criterion)	6	The students will be able to 1. state the definitions of Machine and Mechanism 2. have comprehensive ideas about kinematic chains and pairs 3. determine DOFs of different mechanisms 4. have comprehensive idea about kinematic inversions and Grashof's criteria
Position analysis of planar mechanisms	Loop closure equations, Graphical and analytical solutions of loop closure equations	3	The students will be able to Perform position analysis of given mechanisms by both graphical and analytical methods
Graphical methods of velocity analysis	Relative velocity method, velocity polygon, Instantaneous Centre (IC) of velocity, Aronhold-Kennedey theorem, Circle diagram, Velocity analysis by IC method	4	The students will be able to Perform velocity analysis of given mechanisms by graphical method
Graphical methods of acceleration analysis	Relative acceleration method, acceleration polygon, Normal, Tangential and Coriolis component of acceleration- examples	3	The students will be able to Perform acceleration analysis of given mechanisms by graphical method
Analytical Methods	Analytical methods of velocity and acceleration analysis	2	The students will be able to perform velocity and acceleration analysis of given mechanisms by analytical method

Dimensional Synthesis of mechanisms	Function generation, path generation and body guidance, Freudenstein's equation, Two and Three position synthesis	4	The students will be able to carry out dimensional synthesis of mechanisms using different methods
Cam	Classifications, Analysis of follower motion, Cam profile synthesis, Example Problems	7	The students will be able to 1. classify the cams, state the uses of the cams 2. state and apply the fundamental law of cam design 3. perform analysis of follower's motion 4. carry out cam profile synthesis using both graphical and analytical methods 5. solve related problems
Gears and Gear trains	Fundamental law of gearing, Geometry of involute tooth profiles, interference, undercutting and contact ratio, Spur, helical, and bevel gears-nomenclatures, Epicyclic gear trains, Example Problems	8	The students will be able to 1. state the requirement of gear mechanism 2. derive and apply the fundamental law of gearing 3. have comprehensive idea about involute gear profile and associated topics 4. have comprehensive idea about the nomenclature and associated topics related to different types of gears 5. have comprehensive idea about the gear trains, differential 6. solve problems related to gears and gear trains
Gear Box	Introduction, Classifications, Kinematics	3	The students should gain comprehensive idea about gear box
Robotics Introduction	Definition, Law of Robotics, Anatomy of a Robot, Degree of Freedom, Geometric Configurations, Robot Specifications	2	The students should have basic idea about robots and robotic manipulators
Robot Arm Kinematics	Review of Rigid Body Rotation- Rotation Matrix, Axis angleor Rodrigues' Rotation Formula, Successive Rotations, Forward Kinematics- Homogeneous Transformation, Representation of Joints and Link, Denavit-Hartenberg Parameters	6	The students should gain comprehensive idea about rigid body rotation and its matrix representation The students should be able to perform forward kinematics using Denavit-Hartenberg parameters
Total		**48**	

Course Outcome	At the end of the course, students should be able to 1. calculate DOFs of different mechanisms 2. use Grashof's criterion effectively 3. perform velocity and acceleration analysis of mechanisms using both graphical and analytical techniques 4. perform dimensional synthesis of mechanism 5. perform kinematic analysis of follower (cam-follower) motion and do profile synthesis of cam 6. have comprehensive understanding of gear mechanism and associated kinematics 7. solve problems related to gear train and gear-boxes 8. perform forward kinematics of robotic manipulators using the Denavit-Hartenberg Parameters

Learning Resources	**Text Book:** 1. Theory of Mechanisms and Machines, Amitabha Ghosh and Asok Kumar Mallik, Affiliated East-west Press, 3rd ed. 2. Robotics and Control by R. K. Mittal and I. J. Nagrath, Tata McGraw-Hill, New Delhi, 2007. 3. Industrial Robotics: Technology, Programming and Applications by M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, Tata McGraw-Hill, New Delhi, 2008. **Reference books:** 1. Theory of Machines and Mechanisms, J. J. Uicker, G. R. Pennock and J. E. Shigley, Oxford University Press (Oxford international student edition). 2. Theory of Machines, S. S. Rattan, Tata MaGraw Hill Education Private Limited, Third edition.

4th Semester

Course Code	ME2203N	Course Name	Machine Tools and Metal Cutting	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	*Nil*
Course Offering Department	Mechanical Engineering	**Data Book / Codes/Standards**	*Nil*		

Course Objective	The course aims in • Understanding the concept and definition of machining and machine tools. • Understanding concept of generatrix and directrix, kinetic chains and structures of conventional machine tools. • Studying the Mechanics of machining, tool geometry in orthogonal and ASA systems. • Understanding the Merchant's diagram and analysis of machining forces. • Elucidation of the applications of different machining processes.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	Concept and definition of machining and machine tools, Concept of generatrix and directrix.	02	• Understanding the fundamentals of machining operations.
II	Kinetic chains and structures of conventional machine tools.	02	• In-depth knowledge on Kinetic chains and structures of conventional machine tools.
III	Various mechanisms for transformation and transfer of motion in machine tools. Differential mechanisms.	04	• Understanding the various mechanisms for transfer of motion in machine tools.
IV	Classification of machine tools. Fixed automation.	02	• Fundamental knowledge on Classification of machine tools. Fixed automation.
V	Lathe – specifications, types, functions of various parts, various operations.	04	• Comprehensive knowledge on Lathe, its specifications, types, functions of various parts, various operations.
VI	Shapers and Planers: specifications, types, functions of various parts.	04	• Comprehensive knowledge on Shapers and Planers, their specifications, types, functions of various parts, various operations.
VII	Accuracy-Alignment-Inspection of machine tools.	02	• Understanding the fundamentals of accuracy, alignment and inspection of machine tools.
VIII	Metal cutting: mechanics of machining.	02	• Understanding the fundamentals of mechanics of machining.

IX	Tool geometry in Orthogonal and ASA systems. Tool angles. Conversion of tool angles from one system to other.	04	• Comprehensive knowledge on tool geometry in Orthogonal and ASA systems.
X	Mechanism of chip formation, chip morphology, types of chip, and formation of Built-Up-Edge (BUE).	04	• Understanding the fundamentals of mechanism of chip formation, chip morphology and types of chip.
XI	Forces in machining operation, Merchants diagram, velocity relationship, derivation of specific energy terms.	04	• In-depth knowledge on Merchants diagram and force analysis in orthogonal machining operation.
XII	Cutting temperature and cutting fluid.	02	• Thorough knowledge on application of different types of cutting fluids during machining operations.
XIII	Failure, wear and life of cutting tools. Taylor's tool life equation. Basic concepts of on-line tool condition monitoring.	04	• In-depth knowledge on Taylor's tool life equation, tool wear, tool failure and tool condition monitoring.
XIV	Cutting tool materials.	02	• Thorough knowledge on different types of cutting tool materials and their usage.
Total		**42**	

Course Outcome	After successful completion of the course, the student shall be able to • Understand the kinetic chains and structures of conventional machine tools. • Know the specifications, types, functions of various parts, various operations of Lathe, Shaper, Plane and other machine tools. • Analyse cutting forces by Merchant's circle diagram. • Predict the tool life by Taylor's tool life equation.

Learning Resources	**Text Books:** 1. Materials and Processes in Manufacturing by E.P. DeGarmo, J.T. Black, R.A Kohser, Prentice Hall of India Pvt. Ltd. 2. Manufacturing Technology by P. N. Rao, Tata McGraw-Hill Publishing Company Limited. 3. A Textbook of Manufacturing Technology by P. C. Sharma, S. Chand and Company Limited. **Reference Books:** 1. Manufacturing Processes for Engineering Materials by S. Kalpakjian and S.R. Schmid, Pearson Education India Ltd. 2. Production Technology, HMT, Tata McGraw-Hill Education

4th Semester

Course Code	ME2221N	Course Name	Numerical Methods in Engineering	Course Category	OE1	L	T	P
						3	0	0

Pre-requisite Courses	Engineering Mathematics (Math-I, Math-II) or Mathematics with same topics of Engg. Math.	Co-requisite Courses	Numerical Methods in Engineering Laboratory	Progressive Courses	The knowledge of this course will be required in almost all the subjects where solving equations, doing interpolation, curve fitting are necessary
Course Offering Department	*Mechanical Engineering*			**Data Book / Codes/Standards**	*Nil*

Course Objectives	The goal of the course is to provide students with a comprehensive understanding of various numerical methods used in engineering analysis. The specific objectives are to develop skills in applying various numerical methods to solve problems in various engineering disciplines, understand the limitations and advantages of different methods, and analyze the accuracy of solutions.

Module	Syllabus	Duration (class-hour)	Module Outcome
Introduction	Introduction to Numerical Methods, Relevance of numerical methods in present day engineering	2	Students will be able to understand the origin and basis of numerical methods and realize its vast applications and relevance in today's world
Types of Errors	True and approximate error, Absolute error and relative error, Truncation and Round-off Errors, Error due to computer representation of numbers, Causes of error. Propagation of Errors.	2	Students will realize the importance of error in numerical methods. They will be able to tell about different types of errors, the causes of errors and how the errors propagate
Solution of transcendental equations	Graphical Methods, Numerical Methods: (Bracketing Methods) Method of Bisection, Regula-Falsi method; (Open Methods) Fixed point iterative methods, Newton-Raphson method, Secant Method. Algorithm Development and determining the order of convergence.	3	The students will be able to understand and apply different bracketing and open methods to solve transcendental equations. They will also be able to determine the order of convergence of open methods. They will also be able to visualize how the intervals get reduced in open methods.
Solution of Polynomial Equations and System of nonlinear equations	Roots of polynomial equations by Lin-Bairstow's method. Solution of a system of nonlinear equations by the Newton-Raphson method.	3	Students will be able to learn and apply the Lin-Bairstow's method to find the roots of polynomial equations. Students will be able to apply the Newton-Raphson methods to solve system of nonlinear equations
Solution of a set of linear algebraic equations	Direct Methods: Gaussian elimination method with partial pivoting, Evaluation of determinant of the coefficient matrix, Algorithm development, Examples. Gauss-Jordan method and LU-Decomposition (Doolittle's) method. Algorithm development, Examples. Matrix Inversion,	7	The students should be able to learn and apply different direct methods to solve system of linear equations, to obtain inverse of a matrix, determinant of matrix.

	Calculation of multiplication/division FLOPS for each method. Condition of an equation set: Condition Index, Condition number. Iterative Method: Gauss-Seidel method. Convergence criteria. Gauss-Seidel method with relaxation, Examples.		The students should be able to tell issues with different direct methods. They will be able to calculate the FLOPs and tell importance of it. The students should be able to the need to have understanding of condition number and able use the idea and formula of condition number. They will also be able to learn and apply the Gauss-Seidel method. They will also be able to interchange the equations based on convergence criteria. The importance of relaxation should be learned by the students.
Curve fitting: Linear and Nonlinear Regression	Meaning, importance and application. Difference with interpolation. Linear regression using the least-square method. Matrix formulation of the least square procedure for linear forms, Weighting factors, Curve fitting with polynomials. Standard error, Curve fitting using non-linear forms. Examples	5	Students should be able to understand the fundamental concepts behind curve fitting using the regression technique. Also, apply the concept to solve problems on curve fitting to a given set of data in various engineering domains and analyse the goodness of fit.
Curve fitting: Interpolation	Interpolation using polynomials: Newton's forward difference and backward difference methods, Lagrange's method. Examples. Interpolation using splines: Difference between polynomial interpolation and spline interpolation. Development of cubic splines for a set of data with different end conditions. Examples	5	Students should be able to understand the fundamental concepts behind curve fitting using various interpolation techniques. Also, apply the concept to solve problems on curve fitting to a given set of data in various engineering domains and evaluate the relative merits/demerits of each method.
Numerical Integration	Newton Cotes formula.Trapeziodal and Simpson's methods. composite forms. Gaussian quadrature using Legendre polynomials. Examples.	4	The students will be able to learn and apply different Newton-Cotes methods along with the Gaussian quadrature method to perform numerical integration. They will also be tell the order of error associated with these methods.
Solution of ODE, Initial Value Problems	Definition of initial value problem. Solution of ordinary differential equation: Euler's method, Modified Euler's method, both self-starting type and non-self starting type. Midpoint method. Error estimation, Examples. Family of Runge-Kutta methods, Classical 4^{th} order Runge-Kutta method. Solution of simultaneous equations using 4^{th} Order Runge-Kutta method. Algorithm development, Examples.	5	The students will be able to write the general problem statement related to initial value problem. The students will be able to learn and apply different numerical methods to solve ordinary differential equations (initial value problem) numerically. They will also be tell the order of error associated with these methods.
Solution of ODE, Boundary	Definition of Boundary Value Problems, Solution of ODE depicting boundary value problems using the Finite Difference method	4	The students will be able to write the general problem statement related to boundary value problem. The students will be able to tell

Value Problems			different types of boundary conditions. The students will be able to learn and apply finite difference method.
Total		**40**	

Course Outcome	At the end of the course, students should be able to 1. Understand the fundamental concepts behind various numerical methods 2. Apply their learning to solve engineering problems in various domains 3. Analyze the errors/accuracy of the solutions 4. Evaluate the relative merits and demerits of each numerical method

Learning Resources	**<u>Text Books</u>** 1. Numerical Methods for Engineers, 4thEdition, by Steven C. Chapra and Raymond P. Canale, McGraw-Hill Companies, 2002. 2. Applied Numerical Methods for Digital Computation, 4th Edition, by M.L. James, G.M. Smith and J.C. Wolford, Addison-Wesley Longman Publishing Co., Inc., 1984. 3. Numerical Methods: Principles, Analyses, and Algorithms, by Srimanta Pal, Oxford University Press, 2012. 4. Numerical Methods for Scientists and Engineers, by Richard Hamming, Dover Books Publications, 1987.

5th Semester

Course Code	ME3101N	Course Name	Heat Transfer	Course Category	PC	L	T	P
						3	1	0

Pre-requisite Courses	Thermodynamics & Fluid Mechanics	Co-requisite Courses	*Nil*	Progressive Courses	Computational Fluid Dynamics and Heat Transfer
Course Offering Department	Mechanical Engineering	**Data Book / Codes/Standards**	Nil		

Course Objective	The objectives of this course are to ensure that the students can • Understand the fundamentals of heat transfer processes occurring in natural and engineered systems • Apply analytic procedures and numerical tools to solve heat transfer problems • Design heat transfer devices such as heat exchangers, etc. • Evaluate the performance of heat transfer devices

Module	Syllabus	Duration (class-hour)	Module Outcome
01	One-Dimensional, Steady-State Conduction: The plane wall, Temperature distribution, Thermal resistance, The composite wall Contact resistance, Radial Systems; Summary of One-Dimensional Conduction Results, Conduction with thermal energy generation; The plane wall; Radial Systems, Heat Transfer from Extended Surfaces; A general conduction analysis, Fins of uniform cross-sectional area; Fin performance; Fins of non-uniform cross-sectional area; overall surface efficiency	08	• Students will be able to understand, formulate and solve conduction heat transfer problems that can be reduced to one dimension. • Students will be able to analyze problems involving fins.
02	Two-Dimensional, Steady-State Conduction: The method of separation of variables, The graphical method, Methodology of constructing a flux plot; Determination of the heat transfer rate, The conduction shape factor, Finite-Difference equations; Finite-difference form of the heat equation; Finite-difference solutions; The matrix inversion method; Gauss-Seidel iteration	05	• Students will be able to understand, formulate and solve conduction heat transfer problems that can be reduced to two dimensions. • Student will get an idea of numerical solution of conduction problems.
03	Transient Conduction: The lumped capacitance method, Validity of the lumped capacitance method, General lumped capacitance analysis, Spatial effects ,The plane wall with convection, Exact solutions, Approximate solutions, Total energy transfer, Radial Systems with convection, Exact solutions, Approximate solutions, The semi-infinite solid Multidimensional effects, Finite-difference Methods	03	• Students will be able to understand, formulate and solve unsteady conduction heat transfer problems.
04	Introduction to convection: The convection transfer problem, The Convection boundary layers, The velocity boundary layer, The thermal boundary layer, Significance of the boundary	04	• Student should be able to understand the fundamental concepts of convective heat transfer

	layers, Laminar and turbulent flow, The convection transfer equations, The velocity boundary layer, The thermal boundary layer, The concentration boundary layer, Approximations and special conditions, Boundary layer similarity: The normalized convection transfer equations, Boundary layer similarity parameters, Functional forms of the solutions, Physical significance of the dimensionless parameters, Boundary layer analogies, The Reynolds analogy, The effects of turbulence, The convection coefficients		• The close inter-relationship between convective heat transfer and fluid mechanics must be clear to the students
05	External flow: The Empirical Method , The Flat Plate in Parallel Flow, Laminar Flow over an Isothermal Plate: A Similarity Solution, Turbulent Flow over an Isothermal Plate, Unheated Starting Length, Flat Plates with Constant Heat Flux Conditions, Limitations on Use of Convection Coefficients, Methodology for a Convection Calculation, The Cylinder in Cross Flow, Flow Considerations, The Sphere, Flow Across Banks of Tubes	03	• Students should be able to quantify heat transfer in convection by determining the convective heat transfer coefficient for various external flow conditions
06	Internal flow: Velocity Profile in the Fully Developed Region, Pressure Gradient and Friction Factor in Fully Developed Flow: The Mean Temperature, Newton's Law of Cooling, Fully Developed Conditions, The Energy Balance, General Considerations, Constant Surface Heat Flux, Constant Surface Temperature, Laminar Flow in Circular Tubes: Thermal Analysis and Convection Correlations, The Fully Developed Region, The Entry Region, Convection Correlations: Turbulent Flow in Circular Tubes, Convection Correlations	03	• Students should understand the various conservation equations relevant to convective heat transfer, particularly for internal flow • They should also be capable of solving these equations analytically and, where appropriate, numerically for simple geometries under specified boundary conditions.
07	Boiling and Condensation, Heat Exchangers	04	• Students should gather preliminary knowledge about the heat transfer during boiling and condensation • Should be able to analyze the performances of different types of heat exchanger
08	Radiation: Fundamental Concepts, Radiation Heat Fluxes, Radiation Intensity, Mathematical Definitions, Radiation Intensity and Its Relation to Emission, Relation to Irradiation, Relation to Radiosity for an Opaque Surface, Relation to the Net Radiative Flux for an Opaque Surface, Blackbody Radiation , The Planck Distribution, Wien's Displacement Law, The Stefan–Boltzmann Law , Band Emission, Emission from Real Surfaces, Absorption, Reflection, and Transmission by Real Surfaces, Absorptivity, Reflectivity, Transmissivity, Special Considerations, Kirchhoff's Law, The Gray Surface	06	• Students should be able to explain different terminologies and laws used in radiation heat transfer
09	Radiation Exchange between Surfaces: The View Factor, The View Factor Integral, View Factor Relations, Blackbody Radiation Exchange, Radiation Exchange Between	06	• Students should be able to calculate radiation heat transfer for different surfaces and different geometries

	Opaque, Diffuse, Gray Surfaces in an Enclosure, Net Radiation Exchange at a Surface, Radiation Exchange between Surfaces, Electrical Analogy, The Two-Surface Enclosure, Two-Surface Enclosures in Series and Radiation Shields		• They should also be able to apply the electrical analogy to analyze radiation heat transfer problems.
Total		**42**	

Course Outcome	CO1:Understand the fundamentals of heat transfer processes CO2: Identify, formulate, and solve engineering problems by applying principles of heat transfer. CO3: Develop and conduct appropriate experimentation, and interpret associated data CO4: Evaluate and assess the utility and efficiency of various heat transfer devices

Learning Resources	**Text books:** 1. Heat Transfer - F P Incropera and D P De Witt, T L Bergeman, A S Lavine, J Wiley & Sons 2. A Text Book of Heat and Mass Transfer- R K Rajput, S Chand **Reference books :** 1. Heat Transfer - Frank Kreith and Raj M. Manglik, Cenage Learning 2. Heat Transfer - J P Holman, McGraw-Hill 3. Heat Transfer: A Practical Approach- Yunus A. Cengel

5th Semester

Course Code	ME3102N	Course Name	Design of Power Transmission Elements	Course Category	PC	L	T	P
						3	1	0

Pre-requisite Courses	*Fundamentals of Machine Design; Strength of Materials*	Co-requisite Courses	Design of Power Transmission Elements Sessional	Progressive Courses	Design of Frictional Machine Elements
Course Offering Department	*Mechanical Engineering*	**Data Book / Codes/Standards**	*Machine Design Data Book*		

Course Objectives	The goal of the course is to provide students with comprehensive knowledge and skills required for designing and analyzing machine elements involved in mechanical power transmission systems. The specific objectives are to equip students with the fundamental concepts of some of the major power transmission elements, analysis of the forces acting on such machine elements, the design procedures based on the knowledge of various theories of failures, and the use of data and catalogs in the design process.

Module	Syllabus	Duration (class-hour)	Module Outcome
Design of Helical Spring	Classification, Construction of a helical spring, nomenclatures and definitions; Derivation of maximum shear stress expression including Wahl's correction factor, deflection. Design of spring dimensions based on both strength and stiffness under static and dynamic loading, Spring surge, Design of cluster springs.	06	Students (i) will learn classification of various types of coiled springs with an emphasis on helical cylindrical springs with nomenclatures, various dimensions and important design parameters of such springs, (iii) will learn derivation of expressions of maximum stress and deflection while taking curvature effects into account, (iv) will learn to design standard spring dimensions based on strength, stiffness and surge under static and variable loads.
Design of power transmission shaft and Design of keys	Definition of shaft and axle, Properties of shaft material, Design of shaft based on strength under torsional moment, bending moment and axial load as per ANSI/ASME standard B106.1M-1985; Design of shaft based on stiffness considering transverse deflection, slope and torsional rigidity, Design of shaft based on critical speed using Rayleigh Ritz method. Types of keys and applications, key material, and Design of keys based on different failure types.	09	Students will learn (i) difference between shafts and axles, shaft materials, design considerations of transmission shafts, (ii) design of shafts based on strength, stiffness and stability under static and variable loading as per ANSI/ASME standard B106.1M-1985; (iii) about various types of keys and keyways, key materials and design of keys.
Spur Gear	Purpose, Classifications and Applications, Nomenclatures of spur gears, law of gearing and interference; Forces induced on each gear of compound and epicyclic gear train, Gear materials, Derivation of Lewis equation based on strength and design of module, checking of design using Buckingham's dynamic load. Wear on a gear tooth, Possible causes in the light of Hertzian contact state of stress. Derivation of	09	Students will learn (i) Gear terminology, tooth profiles, calculation of contact ratio, check occurrence of interference, (ii) great trains and force analysis of various gear trains with bearing reactions, (iii) to design module and number of teeth required for the gear based on

	Buckingham's wear load formula from Hertz's contact stress formula for a pair of spur gear teeth and its use in further checking of design.		Lewis equation with checking against dynamic load and wear
Helical Gear	Purpose, Classifications and Applications, Nomenclatures of helical gear, Speed ratio and interference, Concept of virtual number of teeth of a helical gear, Force analysis of a helical gear drive, Modified Lewis equation in designing a helical gear tooth, Modified dynamic load and wear load formula of Buckingham. Problems on force Analysis and design of helical gears.	05	Students will learn (i) Helical Gear terminology, tooth profiles, calculation of contact ratio, formative number of teeth, interference, (ii) Difference between transverse and normal plane and corresponding parameters, (iii) force analysis to calculate gear forces and bearing reactions, (iii) to design module and number of teeth required for the gear based on Lewis equation with checking against dynamic load and wear.
Design of Bevel Gear	Purpose, Classifications and Applications, Nomenclatures of bevel gear and definition of various parameters of a bevel tooth, derivation of virtual number of teeth of a bevel gear, force analysis of bevel gear drive, Modified Lewis equation for bevel gear tooth, modified dynamic load and wear load formula of Buckingham.	06	Students will learn (i) bevel Gear terminology, tooth profiles, calculation of contact ratio, formative number of teeth, interference, (ii) force analysis to calculate gear forces and bearing reactions, (iii) to design module and number of teeth required for the gear based on Lewis equation with checking against dynamic load and wear.
Design of rolling contact bearings	Construction and designation, Basic static load and Basic dynamic load capacities, Rated Life, Equivalent dynamic load, Selection of ball bearings based on SKF catalogue, Selection of cylindrical and taper roller bearings.	06	Students will learn classification of bearings in detail and selection of appropriate bearings.
Class Test		01	
	Total	**42**	

Course Outcome	At the end of the course, students should be able to 1. Understand the working principles and design procedures of various power transmission elements 2. Select appropriate components for different power transmission applications. 3. Calculate design parameters for different elements and analyze power transmission systems under different loading conditions. 4. Apply design concepts to estimate the strength of various power transmission elements under different loading conditions. 5. Design various power transmission elements, such as gears, power transmission shaft, helical spring and rolling contact bearings. 6. Use standard data, catalogues, and resources for design purposes effectively.

Learning Resources	**Text Books** 1. Mechanical Engineering Design (6th International Edition), by J.E. Shigley and C.R. Mischke, McGraw-Hill Publications, 2001 2. Machine Design: An Integrated Approach (3rd Edition), by Robert L. Norton, Prentice Hall, 2006. 3. Fundamentals of Machine Component Design (3rd Edition), by Robert C. Juvinall and Kurt M. Marshek, Wiley Student Edition, 2007. 4. Machine Design Data Book, by V.B. Bhandari, Chennai McGrawHill Education,2nd Edition, 2019. **Reference Books** 1. Shigley's Mechanical Engineering Design (8th Special Indian Edition), by J.E. Shigley, Charles R. Mischke, Richard G. Budynas and Keith J. Nisbett, The McGraw-Hill Companies, 2008. 2. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980. 3. Design of Transmission Systems, by P. Kannaiah, SCITECH Publications Pvt. Ltd., 2007.

5th Semester

Course Code	ME31XXN	Course Name	Dynamics and Vibration of Machines	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*Math-I & II Mechanics, Rigid Body Dynamics, Mechanism and Manipulator*	Co-requisite Courses	*Nil*	Progressive Courses	*Machine Design, Robotics, Analytical Mechanics, Control System Engineering*
Course Offering Department	*Mechanical Engineering*			**Data Book / Codes/Standards**	*Nil*

Course Objective	The goals of the course are 1. to provide students with comprehensive understanding of force analysis of four bar mechanisms, slider-crank mechanism to equip them with relevant techniques 2. to provide students with comprehensive understanding of Flywheel design 3. to provide students with comprehensive understanding of rotating and reciprocating balancing and to equip them with relevant techniques 4. to provide students with comprehensive understanding of 3D rigid body dynamics 5. to provide students with comprehensive understanding of the machine vibration 6. to provide techniques to do modelling and to do vibration analysis of free and forced lumped and continuous systems

Module	Syllabus	Duration (class-hour)	Module Outcomes
Static and Dynamic Force analysis of planar mechanisms	Force analysis of four bar mechanisms Engine force analysis Dynamically equivalent system Turning Moment on crankshafts, turning moment diagram	5	The students will be able to 1. derive equations of a given mechanism 2. perform engine force analysis 3. have comprehensive idea about dynamically equivalent link and its usefulness 4. obtain expressions of turning moment and its correction
Design of Flywheels	Fluctuation of energy and speed Design and analysis of flywheels for engines and punching press	5	The students will be able to 1. gain comprehensive idea about flywheels and its necessity 2. design and analyze flywheel for engine and punching press
Balancing	Static unbalance and static balancing Dynamic Unbalance and its analysis Balancing machines Field Balancing- balancing of thin discs, balancing of rigid rotors Balancing of reciprocating parts Balancing of single-cylinder engines Balancing of multi-cylinder engines Analytical technique of balancing of reciprocating engines Balancing of linkages Balancing standards and codes	10	The students will be able to 1. gain comprehensive idea about the need and the procedure of balancing of unbalance (both rotating and reciprocating) 2. differentiate between static and dynamics balancing 3. apply balancing methods (rotating) to solve given problems 4. have comprehensive idea about field balancing and apply it 5. to apply methods to perform engine balancing 6. have comprehensive idea about balancing of linkages

			7. remember and apply balancing codes
Gyrodynamics	Euler Equations for 3-D rigid body dynamics Tops and conventional Gyroscopes Gyroscopic Moment Optical and MEMS gyroscopes	8	The students will be able to 1. derive and have comprehensive idea about Euler-Newton equations 2. apply Euler-Newton equations for different systems
Vibration Analysis	Lumped parameter models of elastic machine members, differential equations of motion, natural frequency. Free and forced vibration of single degree-of-freedom systems Viscous and dry friction damping, measurement of damping Vibration Isolators Two Degrees-of-Freedom systems Vibration absorber	14	The students will be able to 1. have comprehensive idea about vibration of mechanical systems 2. model a given mechanical system in the context of vibration analysis 3. derive equation of motions 4. have comprehensive idea about free and forced vibrations of SDOF and MDOF systems 5. have comprehensive idea about natural frequency, damping, resonance 6. have comprehensive idea about vibration isolators and absorbers
	Total	**42**	

Course Outcome	At the end of the course, students should 1. be able to perform force analysis in four bar and slider-crank mechanisms using static/dynamic equations/equations of motion 2. have understanding of dynamically equivalent link, turning moment of crankshaft 3. be able to reason out the requirement for flywheel, to find the mass moment of inertia and size of the flywheel 4. be able to perform rotating and reciprocating balancing of rotors and slider-crank mechanism, respectively 5. be able to reason out the difficulty in complete balancing of four bar mechanism 6. be able to derive and apply Euler-Newton's equations to different problems 7. have the idea of modelling procedure in the context of machine vibration and be able to derive equations of motion 8. have comprehensive idea about free, forced vibration of SDOF and MDOF systems, natural frequency, resonance, damping 9. have comprehensive idea about vibration isolator and vibration absorbers

Learning Resources	**Text Book:** Theory of Machines and Mechanisms, Amitabha Ghosh and Asok Kumar Mallik, Affiliated East-west Press, 3rd ed. **Reference books:** 1. Theory of Machines and Mechanisms, J. J. Uicker, G. R. Pennock and J. E. Shigley, Oxford University Press (Oxford international student edition). 2. Principles of Vibration, B. H. Tongue, Oxford University Press (Indian edition).

5th Semester

Course Code	ME31XXN	Course Name	Manufacturing Technology	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	Machine Tools and Metal Cutting	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Objectives	The course aims in • Understanding the concept of multipoint machining. • Understanding the specifications, types, functions of various parts and different operations of milling, broaching, grinding and honing machines. • Understanding the fundamentals of metal working processes and sheet metal forming operations. • Imparting in-depth knowledge on various cold forming and hot forming operations. • Elucidation of the defects in metal forming operations.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	Milling machine: specifications, types, functions of various parts, various operations.	06	• Understanding the fundamentals of milling machines and milling operations.
II	Indexing methods – simple compound and differential indexing. Gear cutting.	06	• In-depth knowledge on Indexing methods and their applications.
III	Grinding machine - types of grinding machines, various grinding operations; Grinding wheels, preparation for wheel operation.	06	• Understanding the fundamentals of grinding machines and grinding operations.
IV	Multipoint Machining - Broaching and Reaming.	04	• Thorough knowledge on principle, analysis and applications of broaching and reaming operations.
V	Finishing Operations - Honing and Lapping.	04	• Comprehensive knowledge on honing and lapping processes.
VI	Fundamentals of plasticity, yield and flow, anisotropy, instability, limit analysis, slipline field theory.	04	• Understanding the fundamentals of plasticity, yield, slipline field theory.
VII	Metal forming processes: Types of forming, mechanism of forming.	02	• Understanding the fundamentals of different types of metal forming processes.
VIII	Fundamentals of metal working processes and Sheet metal forming operations.	08	• In-depth knowledge on principle, analysis and applications of different metal forming processes.
IX	Defects in metalworking processes.	02	• Comprehensive knowledge on different kinds of defects in metalworking processes.
Total		**42**	

Course Outcome	After successful completion of the course, the student shall be able to • Understand the principles of multipoint machining processes. • Know the specifications, types, functions of various parts, various operations of Milling machine, Broaching machine, Grinding machine, Honing machine. • Know the fundamentals of metal working processes and Sheet metal forming operations. • Analyse the defects in metal forming operations.

Learning Resources	**Text Books:** 1. Manufacturing Science by A. Ghosh and A. K. Mallik, Affiliated East-West Press Pvt. Ltd. 2. Manufacturing Process for Engineering Materials, by S Kalpakjian & SR Schmidt, Pearson Education India Ltd. 3. Mechanical Metallurgy, GE Dieter, McGraw Hill Company. **Reference Books:** 1. Materials and Processes in Manufacturing by E.P. DeGarmo, J.T. Black, R.A Kohser, Prentice Hall of India Pvt. Ltd. 2. Principle of Industrial Metal Working Process, GW Rowe, CBS Publication, New Delhi.

5th Semester

Course Code	ME3121N	Course Name	Refrigeration and Air-Conditioning	Course Category	OE2	L	T	P
						3	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book / Codes/Standards	Nil

Course Objectives	• Provide concepts of different refrigeration and air conditioning systems • Use of refrigerants and their properties • Summer and winter air conditioning systems, • Heating and cooling load calculations

Module	Syllabus	Duration (class-hour)	Module Outcome
I	Vapour Power cycle: Introduction; History of Refrigeration and Air conditioning, Applications, Reverse Carnot cycle and COP of refrigeration and heat pump; Simple saturated cycle, Actual VCR cycle, Improvement options: liquid sub-cooling, superheated vapor at suction; Liquid-suction heat exchange; Multistage, multi-evaporator and cascade systems	8	• Fundamentals of Vapour compression refrigeration cycle, • Recapitulation of basic thermodynamic cycles, • Advance refrigeration cycles • Problem solving skill
II	Vapour absorption refrigeration systems;:Water-Lithium Bromide and Ammonia-Water Pairs.	5	• Fundamentals of Vapour absorption refrigeration cycle, • Ammonia enrichment process. • Problem solving skill, thermodynamic property of binary mixture
III	Air cycle refrigeration: Reversed Brayton Cycle, Ram Compression, Boot Strap with its variation, Reduced Ambient with its variation	4	• Air refrigeration cycle analysis • Application and problem solving skill
IV	Refrigerants: Properties, nomenclature and designation	3	• Different types of refrigerant • application and limitations
V	System components: Compressors, condensers, expansion valves and evaporators.	6	• Components of air conditioning systems • Design aspects
VI	Review of Psychrometry; Moist air properties Psychrometric Processes inair-conditioning, Room sensible heat factor (RSHF), Cooling coil and bypass factor, Air washer	4	• Psychrometry principle • Properties of moist air
VII	Air conditioning: Human comfort; Inside and outside design conditions, Psychrometry of Air Conditioning Systems: Summer air conditioning with 100% recirculation and partial recirculation, Room load Vs coil load, Winter Conditioning and All-Year Air	8	• Human comfort and industrial air conditioning • Load calculation

	Conditioning Systems, Cooling And Heating Load Calculations -Solar Radiation Through Fenestration, Fabric Heat Gain/Loss, Ventilation And Infiltration, Estimation of Required Cooling/Heating Capacity Balance point outdoor temperature and its relevance, Evaporative Air Conditioning Systems; direct, indirect and cascade		
VIII	Types of Air Conditioning Systems and their selection, Air Transmission and Distribution: Air handling units (AHU), Ducts and blowers, Safety in air conditioning systems	4	• Selection of air condition systems • design of distribution systems
	Total	**42**	

Course Outcome	• Be able to choose specific type of refrigeration systems based on application and load. • Be able to calculate air conditioning load • Acquire idea of air conditioning system design • Be able to pursue advance research on the field of air conditioning

Learning Resources	1. Refrigeration and Air-Conditioning, C P Arora, 2. Refrigeration and Air-conditioning, P L Ballaney 3. Refrigeration and Air Conditioning, W F Stoecker 4. Refrigeration and Air-Conditioning, NPTEL online resources

5th Semester

Course Code	ME3122N	Course Name	Dynamics of Fluid Flow	Course Category	OE2	L	T	P
						3	0	0

Pre-requisite Courses	Fluid Mechanics	Co-requisite Courses	*Nil*	Progressive Courses	Computational Fluid Dynamics and Heat Transfer
Course Offering Department	Mechanical Engineering	**Data Book / Codes/Standards**	Nil		

Course Objective	The objectives of this course are to ensure that the students can • Understand the fundamental concepts of fluid dynamics and rheology • Apply scaling techniques and numerical tools to solve complex flow problems • Design flow measurement and visualization experiments • Analyze flow problems that do not admit analytical solutions

Module	Syllabus	Duration (class-hour)	Module Outcome
01	Eulerian and Lagrangian description of motion, Reynolds Transport theorem	02	• Students will be able to understand and formulate a fluid flow problem in different reference frames.
02	Fluid rheology, modelling non-Newtonian viscosity, measurement of viscosity	05	• Students will be able to understand and model non-Newtonian flows
03	Conservation equations for mass, momentum (Navier-Stokes) and energy, Some exact solutions of Navier-Stokes equation: Stokes first and second problems, pipe flow, thin film flow	08	• Students will be able to formulate different flow situations and develop analytical solutions for those.
04	Scaling analysis for boundary layer flow, Similarity Solutions for flow over a flat plate, Stretching Transformation, numerical method to solve similarity equations (shooting technique)	06	• Students will be made aware of the concept of scaling analysis. • Students can develop codes to solve self-similar equations.
05	Different flow measurement techniques such as ultrasonic flowmeter, magnetic flowmeter, vortex flowmeter, turbine flowmeter, and flow visualization techniques such as DPIV, refractive index methods, surface flow visualization, advanced smoke visualization	06	• Students will be acquainted with different flow measurement and visualization techniques.
06	Compressible flow, nozzles, diffusers, convergent-divergent nozzle, shock waves: normal and oblique shocks, shock tables, estimation of shock position, shock tubes	08	• Students will be able to formulate and solve different compressible flow situations problems.
Total		**35**	

Course Outcome	After completion of this course, students will be able to CO1:Understand and formulate different flow problems. CO2:Apply scaling techniques and numerical methods to solve problems that do not admit analytical solutions

	CO3: Evaluate compressible flow situations CO4: Create experimental flow measurement setups

Learning Resources	**Text book :** 1. Viscous Fluid Flow - F M White, McGraw Hill **Reference books :** 1. Mechanics of Fluids – B Massey, CRC Press 2. Fluid Mechanics – P K Kundu, I M Cohen, D R Dowling 3. An Introduction to Fluid Dynamics – G K Batchelor

5th Semester

Course Code	ME3123N	Course Name	Analytical Mechanics	Course Category	OE2	L	T	P
						3	0	0

Pre-requisite Courses	*Engineering Mathematics (Math-I, II), Engineering Mechanics*	Co-requisite Courses	*Nil*	Progressive Courses	*Robotics, Control System Engineering*
Course Offering Department	*Mechanical Engineering*			**Data Book / Codes/Standards**	*Nil*

Course Objective	The goal of the course is to provide students with comprehensive understanding of classical mechanics. The students with understanding of Newtonian Mechanics will learn to derive equations of motions of different systems (discrete as well as continuous) without using Newton's Laws of Motion.

Module	Syllabus	Duration (class-hour)	Module Outcomes
Frames, Equation(s) of Motion using Newton's Laws of Motion	Newton's Laws of Motion, Inertial and Non-inertial frames; Equation of motion of a particle, Equations of motion of a system of particles	2	The students should be able to revise the basics of mechanics and enhance the understanding of it
Coordinates and Constraints	Degrees of Freedom (DOF), Generalized Coordinates, Configuration Space, Holonomic and Non-holonomic constraints, Example Problems	5	The students will be able to gain comprehensive understanding regarding 1. generalized coordinates 2. configuration space 3. constraints The students will be able to solve related problems
Rotations and Euler Angles	Noncommutative nature of Rotation, Euler's theorem and the rotation matrix, Successive Rotations, Euler Angles, Alternative form of Rotation Matrix, Rotated Coordinate Systems	6	The students will be able to have detailed and deep understanding about rigid body rotations, rotation matrix, Euler angles, Rotated coordinate systems
Kinetic Energy of a Rigid Body	Angular Velocity, Fact about angular velocity, Inertia Matrix, Derivation of kinetic energy, Example Problems	5	The students will be able to gain understanding of angular velocity, inertia matrix. The students will be able to derive kinetic energy of a given system
Virtual Work	Virtual Displacement, Virtual Work, Applied and Constrained Forces, Principle of Virtual Work, D'Alembert's principle, Generalized Forces, Example Problems	7	The students will be able to 1. have detailed understanding of virtual quantities 2. have comprehensive idea about Principle of Virtual Work, D'Alembert's principle, Generalized Forces 3. solve related problems
Derivation of Euler-Lagrange Equation	Derivation with Holonomic Constraints, Derivation with Non-holonomic Constraints, Lagrange Multiplier, Example Problems	7	The students will be able to 1. derive Euler-Lagrange Equations for different types of constraints

			2. apply Euler-Lagrange Equations
Principle of Least Action	Introduction to Calculus of Variations, Hamilton's Principle, Continuous Systems	7	The students will be able to 1. gain brief understanding of calculus of variations 2. gain understanding of Hamilton's principle 3. apply Hamilton's Principle to continuous systems 4. solve problems related to calculus of variations
Total		**39**	

Course Outcome	At the end of the course, students 1. should be able to tell the difference between inertial and non-inertial frames 2. should have comprehensive idea about DOF, generalized coordinates, configuration space, constraints 3. should have comprehensive idea and understanding about rigid body rotation and angular velocity 4. should have comprehensive idea and understanding about virtual displacement, work and generalized forces 5. should be able to derive Euler-Lagrange Equation 6. should be able to apply Euler-Lagrange Equation 7. should have basic idea about calculus of variations 8. should be able to apply Hamilton's Principle to continuous systems

Learning Resources	**References**: 1. Donald T. Greenwood, Classical Dynamics, Dover Publications. 2. Anindya Chatterjee, Intermediate Dynamics (Lecture Note on Dynamics). Link: https://home.iitk.ac.in/~anindya/bk123.pdf 3. Peter Hagedorn and Anirvan DasGupta, Vibrations and Waves in Continuous Mechanical Systems, John Wiley & Sons.

5th Semester

Course Code	ME3124N	Course Name	Laser Materials Processing	Course Category	OE2	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Objective	To impart knowledge about different types of industrial laser sources and their characteristics along with process control, characteristics and fundamentals of various types of laser material processing technologies.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	Introduction, various types of industrial laser and their application, He-Ne, CO2, Excimer, Nd: YAG, Diode, Fibre laser etc., concept of generation of various types of laser, properties of laser beam, overview of engineering application of laser	06	Impart knowledge about various industrial laser characteristics
2.	Laser beam delivery system, various types of laser optics, output beam characteristics	04	Impart knowledge of laser optics uses
3.	Laser processing fundamentals: Laser beam interaction with metal, semiconductor and insulator, Ultra-short laser pulse interaction, heat flow theory and metallurgical considerations	04	Impart knowledge about laser material interaction
4.	Laser cutting and drilling: Process overview, Process characteristics and control, material removal modes, numerical modelling and examples	04	Understand laser cutting and drilling process
5.	Laser welding: Process mechanisms like keyhole and plasma effect, operating characteristics and process variation	04	Understand laser welding process
6	Laser surface modifications: Heat treatment, surface re-melting, surface alloying and cladding, surface texturing, LCVD and LPVD.	06	Understand laser surface modification process
7	Laser rapid manufacturing: overview of various laser based additive manufacturing processes	04	Application of emerging laser additive manufacturing process
8	Laser metal forming: Mechanisms involved including thermal temperature gradient, buckling, upsetting. Laser peening: Fundamentals of Laser Shock Processing, Effects of various laser and process parameters, Mechanical effects and microstructure modification during laser shock processing.	07	Understand laser metal forming process
9	Economics of Laser Applications in Manufacturing. Laser Safety: Laser safety standards and safety procedures.	02	Impart knowledge about commercial viability of laser application
	TOTAL	**41**	

Course Outcome	Students will develop understanding and specific knowledge about various types of industrial laser sources and their characteristics along with process control and process fundamentals for various laser processing techniques used in industries.

Learning Resources	**Text book** 1. Laser Material Processing by William M. Steen,, 3rd Edition, Springer-Verlag, 2008 2. Principles of Laser Materials Processing by Elijah Kannatey-Asibu, Jr.,, Wiley, 2009 **Reference book** 1. George Chryssolouris, P. Sheng, Frederick F. Ling (Editors), Laser Machining: Theory and Practice, Springer-Verlag, New York, 1991 2. CemilHakanGür, Jiansheng Pan, Handbook of Thermal Process Modelling Of Steels, CRC, 2008 3. Lihui Wang, Jeff Xi (Editors), Smart Devices and Machines for Advanced Manufacturing (Chapter: Laser-Assisted Mechanical Micromachining by Ramesh Singh and Shreyes N. Melkote), Springer-Verlag, 2008

5th Semester

Course Code	ME3125N	Course Name	Welding Technology & Testing	Course Category	OE2	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*			Data Book / Codes/Standards	*Nil*

Course Objective	To impart knowledge on the following topics: 1. ***Define*** the basic theory of welding, its classification, common design of welding joints, types of power sources etc. 2. ***Infer*** the physics of arc, heat transfer and metallurgical aspects, welding defects etc. 3. To ***solve*** the numerical related to arc characteristics, weldability, electron penetration in electron beams etc. 4. ***Analyze*** the nature of heat flow, influence of melt-pool forces, weld quality through destructive and non-destructive testing.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	**Introduction:** Evolution of welding; classification of welding processes; heat sources and shielding methods	6	***Describe*** the basics of joining processes. (CO1) ***Classify*** the different welding processes. (CO2) ***Recognize*** the commonly used heat sources and shielding methods (CO2)
2.	**Physics of Welding Arc** Welding arc; voltage distribution along the arc; thermionic and non-thermionic cathodes; theories of cathode and anode mechanism; arc characteristics and its relationship with power source; arc efficiency; heat generation; effect of type of shielding gas on arc; isotherms of arcs	4	***Demonstrate*** the mechanism of thermionic emission (CO3). ***Examine*** the *V-I*characteristics, change in arc behavior for different input conditions (CO4).
3.	**Welding Power Sources** Conventional welding power sources; constructional features; static and dynamic characteristics; duty cycle; influence of inductance on arc and power source characteristics; internal and external regulation; specific power source requirements; special welding power sources	3	***Lists*** the different power sources used in welding (CO1). ***Demonstrate*** the different arc characteristics (CO3)
4.	**Arc Welding Processes** Consumable electrode welding processes. Manual metal arc (MMA) welding; Gas metal arc welding; pulsed MIG welding; Submerged arc welding, Significance of flux-metal combination; Electro slag welding: heat generation; principle; Gas	5	***Identify*** the available arc welding techniques (CO1). ***Classify*** the keyhole and conduction mode of welding (CO2) ***Show*** the different arc welding processes (CO3).

	tungsten arc welding; selection of polarity, Plasma arc welding; transferred and non-transferred plasma arc welding; selection of gases; welding parameters; keyhole technique.		
5.	**Heat flow in welding** Effect of welding parameter on heat distribution; calculation of peak temperatures; thermal cycles; cooling rate and solidification; Residual stresses and their distribution in welds; influence of residual stresses in static and dynamic loading, distortion	5	***Illustrate*** the influence of welding parameters on heat distribution (CO3). ***Point out*** the thermal cycle and associated residual stress distribution in weld (CO4).
6.	**Design of weld joints** Introduction to design; engineering properties of steels; Type of welds and weld joints; description of welds: terminology, definitions and weld symbols; edge preparation; sizing of welds in structure; Design for Static loading, Weld Calculations in lap, butt and fillet welds; design for fatigue loading, Introduction to Fatigue; nature of the fatigue process; fatigue strength; factors affecting fatigue life; improvement methods for fatigue strength; reliability analysis and safety factors applied to fatigue design.	6	***Outline*** the basics of joint design and its nomenclature (CO1). ***Explain*** the different load acting on the weld (CO2).
7.	**Testing and inspection of weld joints** Chemical tests; Metallographic tests; Hardness tests; Mechanical test for groove and fillet welds-full section, reduced section and all-weld- metal tensile tests, root, face and side bend tests, fillet weld break tests, creep & fatigue testing. Non-Destructive Testing of Weldments; Visual inspection; Dye-penetrant inspection; Magnetic particle inspection; Ultrasonic inspection principle of ultrasonic testing, Radiographic inspection –principle of radiography, X-ray tubes, gamma-ray sources, defect discernibility; Eddy current inspection; Leak tests: N.D.T. Standard procedure for specification and qualification of welding procedure; WPS and PQR, WPQ	6	***Classify*** the destructive and non-destructive techniques (CO2). ***Demonstrate*** the type of weld quality inspection techniques (CO3).
8.	**Weldability of metals** Solidification of weld metal; heat affected zone (HAZ), factors affecting properties of HAZ; gas-metal, slag-metal and solid-state reactions in welding and their influence on soundness of weld joint; lamellar tearing and hydrogen damage; weldability; definition, factor affecting the weldability of steel Carbon equivalent. Weldability of steel, cast iron and aluminium alloys of commercial importance, failure analysis of welded joints.	6	***Outline*** the basics of solidification, weldability etc. (CO1) ***Calculate*** the weldability (CO3).
	TOTAL	**41**	

Course Outcome	After the completion of the course, the students will be able to:- 1. ***Describe*** the fundamentals of different welding techniques, its welding classification, working principle, basic welding symbols, position etc. 2. ***Classify*** the welding symbols, understand the physics of arc behavior, arc forces, principles of weld joint design, metallurgical aspects in welding of steel, welding defects etc. 3. To ***solve*** the numerical related to *V-I* characteristics, weldability, electron penetration in electron beams etc. 4. ***Analyze*** the weld quality through different tests, influence of cooling rate and heat dissipation, check the influence of welding parameters on weld quality etc.

Learning Resources	**Text book** 1. Welding Technology & Design – by V.M. Radhakrisnan; New Age International **Reference book** 1. The Metallurgy of Welding, 6th Edition, Lancaster, William Andrew Publishing, NY. 2. Principles of Welding (Processes, Physics, Chemistry and Metallurgy), Robert and Messler, Wiley Interscience Publishers. 3. Welding Hand Book Vol. 5; 7th edition, AWS, 1984. 4. Welding Metallurgy, S Kou, John Wiley, USA, 2003.

6th Semester

Course Code	ME3201N	Course Name	Steam and Gas Power System	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	CO1: To impart fundamental and applied knowledge of steam and gas power cycles and their major components CO2: Understanding working principles of steam generators and their mountings and accessories. CO3: Understanding working principles of steam nozzles and steam turbines CO4: Understanding working principles of gas turbine based systems for stationary power generation.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	Advanced steam cycle: Superheat, Reheat and Regeneration, Open and closed type heaters, Drip diversion systems	04	To understand the basics of steam power generation.
2.	Steam generators, types, Mountings, Water wall, Superheater, Reheater, Economiser and air preheater, Circulation ratio, Void fraction, Slip ratio, Heat transfer characteristics of heating elements	08	Developing knowledge of steam generators, mountings and accessories.
3.	Draft system: Natural draft system, Forced draft system, Induced draft system, Balanced draft system, Computation of draft.	04	Understanding the draft system in connection to power plants.
4.	Steam Nozzles : Stagnation Properties- Function of nozzle, Types, Flow through nozzles, Velocity at exit, Ideal and actual expansion in nozzle- Velocity coefficient, Condition for maximum discharge and critical pressure ratio, Criteria to decide nozzle shape- Super saturated flow, its effects, Degree of super saturation and Degree of under cooling - Wilson line.	04	Understanding about steam nozzles and related terminologies for steam power applications.
5.	Steam Turbines: History, Impulse, Optimum velocity ratio, Compounding of steam turbines, Impulse-reaction principle and 50% Reaction turbines, Reheat factor and condition line, Losses in steam turbines, Steam turbine governing.	08	Understanding of steam turbines, types and governing phenomenon.
6.	Condenser: Classification and construction, Jet and Surface condensers, Air-ingress and its effect, Air removal, Vacuum efficiency, Related calculations.	06	Developing the basic knowledge of steam condensers for thermal power plants.
7.	Gas turbines and improved Brayton cycle configurations, Regeneration, Inter cooling and Reheating, Closed cycles, Performance parameters, Actual cycle and losses, Merits and Demerits of gas turbine plants, Components and materials of gas turbine plants	08	Understanding the working principle of gas turbine power plants and its components
	Total	**42**	

Course Outcome	• From this course, students will develop a basic understanding of the different components, mountings and accessories of a thermal power plant. • They will also get an exposure to the gas turbine based power generation system. • This understanding will help the students to learn in detail about the thermal and gas turbine based power plants. • This knowledge can help the students to work successfully in the power plants and ancillary industry in their future career.

Learning Resources	**Text books:** 1. Power Plant Engineering by P. K. Nag, Tata McGraw Hill 2. Power Plant Technology by M. M. Ei. Wakil, McGraw Hill Education (India) Pvt.Ltd. **Reference Book:** 1. Principles of Energy Conversion by A. W. Culp, McGraw Hill Education Pvt.Ltd 2. Power Plant Engineering and Economy by B. G. A. Skrotzki and W. A. Vopat, McGraw Hill Education (India) Pvt.Ltd.

6th Semester

Course Code	ME3202N	Course Name	Design of Frictional Machine Elements	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	1) Mathematics I (MA-1101) 2) Mathematics II (MA-1201) 3) Strength of Materials (AM-2101) 4) Numerical Methods in Engineering (ME-2102) 5) Fundamentals of Machine Design (ME-2203) or, equivalent courses	Co-requisite Courses	Design of Frictional Machine Elements Sessional (ME-3272)	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	**Data Book / Codes/Standards**	1) Machine Design Data Book, V. B. Bhandari, McGraw Hill 2) Standard Handbook of Machine Design, J. E. Shigley, C. R. Mischke and T. H. Brown, Jr., McGraw Hill 3) IS 2494-1 (1994) 4) IS 2494-2 (1993) 5) IS 3142 (1993)		

Course Objective	1) The students will be able to design (or, select from the manufacturers' catalogs / standards) machine elements where friction plays an important role 2) The students will be able to determine whether optimization is required and how to implement different optimization techniques, if need be, depending on the problem definition.

Module	Syllabus	Duration (class-hour)	Module Outcome
Design of Infinitely Short Journal Bearings	Basic Assumptions, Petroff's equation of frictional coefficient, Sommerfeld number, Solutions of numerical problems, McKee's coefficient of friction for thermal effect.	7	After successful completion of the module, the students will be able to DESIGN infinitely short journal bearings.**(CO1)**
Design of Worm Gears	Purpose, Classifications and Applications, Nomenclatures and Proportions of Worm Gears, Force Analysis, Friction in Worm Gears, Efficiency of Worm Gear Drive, Selection of Materials, Strength and Wear Rating of Worm Gears, Thermal Considerations	8	After successful completion of the module, the students will be able to DESIGN worm gears.**(CO2)**
Design of Brakes	Purpose, Classifications and Applications, Energy Equations, Block Brake with Short Shoe, Pivoted Block Brake with Long Shoe, Internal Expanding Double Shoe Brake, External Contracting Double Shoe Brake, Band and Disk Brakes, Thermal Considerations.	8	After successful completion of the module, the students will be able to DESIGN brakes.**(CO3)**
Design of Friction Clutches	Single disc clutch, multiple disc clutch, cone clutch and centrifugal clutch. Calculation of slipping time, energy lost in slipping due to disengagement and re-engagement, temperature rise.	8	After successful completion of the module, the students will be able to DESIGN friction clutches.**(CO4)**

Design of Power Screw	Application and material of power screw, Types of threads, condition for self-locking, maximum efficiency, design of components of a power screw based on strength and lubrication aspects.	6	After successful completion of the module, the students will be able to DESIGN power screws.**(CO5)**
Design of V-belt Drive	Problems with data are to be done by charts in sessional classes	6	After successful completion of the module, the students will be able to DESIGN V-belt drives and select necessary components from manufacturers catalog / standard.**(CO3)**
Optimization in Design	Multivariable optimization using Lagrange multiplier method, Kuhn-Tucker conditions for solving generalized optimization problems, Global optimality, Numerical methods of optimization of unconstrained and constrained design problems, Use of OPTIMIZATION toolbox in MATLAB in solving problems on Shaft, Spring, Clutch, Gear Boxes, Flag pole etc.	12	After successful completion of the module, the students will be able to APPLY optimization in design of machine elements.**(CO6)**
Class Test		1	
Total:		**56**	

Course Outcome	After successful completion of the course, the students will be able to: 1) DESIGN infinitely short journal bearings 2) DESIGN worm gears 3) DESIGN brakes and select v-belts from manufacturers catalog 4) DESIGN friction clutches 5) DESIGN power screws 6) APPLY optimization in design of machine elements

Learning Resources	**Text Books:** 1. Mechanical Engineering Design, J.E. Shigley and C.R. Mischke, McGraw-Hill 2. Machine Design: An Integrated Approach, R. L. Norton, Prentice Hall 3. Introduction to Optimum Design, J.S. Arora, Academic Press (Elsevier) 4. Machine Design Data Book, V.B. Bhandari, McGraw-Hill **Reference Books:** 1. Shigley's Mechanical Engineering Design, R. G. Budynas and K. J. Nisbett, McGraw-Hill 2. Schaum's Outline of Theory and Problems of Machine Design, A. S. Hall, A. R. Holowenko and H. G. Laughlin, McGraw-Hill 3. Design of Machine Elements, V.B. Bhandari, Tata McGraw-Hill 4. Optimization: Algorithms and Applications, by R.K. Arora., CRC Press (Taylor and Francis)

6th Semester

Course Code	ME3203N	Course Name	Advanced Manufacturing Technology	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	Manufacturing Technology	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book / Codes/Standards	Nil

Course Objectives	The course aims in • Understanding the need of Non-Traditional Machining in the present industrial scenario. • Understanding the principle, mechanism of material removal of various Non-Traditional Machining processes. • Studying the various process parameters and their effects on the machined components. • Understanding different Hybrid manufacturing processes. • Elucidation of the applications of different processes.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	Introduction to Non-traditional manufacturing processes, Need of Non-traditional manufacturing in the present industrial scenario. Differences between traditional and Non-traditional manufacturing, Classification of Non-traditional manufacturing processes.	04	• Understanding the basics of Non-traditional manufacturing processes.
II	Abrasive Jet Machining (AJM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications.	06	• In-depth knowledge on principle, analysis and applications of AJM process.
III	Ultrasonic Machining (USM): Equipment, Process principles, Operating parameters, Horn design, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications.	04	• Comprehensive knowledge on principle, analysis and applications of USM process.
IV	Water Jet Machining (WJM): Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications.	04	• Thorough knowledge on principle, analysis and applications of WJM process.
V	Chemical Machining (CHM): Equipment, Process principles, Maskants and etchants, Photo-Chemical Machining Advantages, Limitations, Different applications.	04	• Comprehensive knowledge on principle, analysis and applications of CHM process.
VI	Electro-Chemical Machining (ECM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications.	04	• In-depth knowledge on principle, analysis and applications of ECM process.
VII	Electro-Discharge Machining (EDM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), numerical problems on EDM, Wire-Electro-Discharge Machining Process	06	• In-depth knowledge on principle, analysis and

	(WEDM), Advantages, Limitations, Different applications.		applications of EDM and WEDM process.
VIII	Laser Beam Machining (LBM): Fundamentals of lasing process, Lasing materials, Solid-state and gas lasers, Processing with lasers – cutting, drilling, welding, heat treatment, cladding engraving, marking etc.	06	• Comprehensive knowledge on principle, analysis and applications of LBM process.
IX	Electron Beam Machining (EBM): Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications.	04	• Comprehensive knowledge on principle, analysis and applications of EBM process.
Total		**42**	

Course Outcome	After successful completion of the course, the student shall be able to • Understand the principle of working, mechanism of material removal in the various Non-traditional machining processes. • The student shall also be able to identify the process parameters, their effects and applications of different Non-traditional processes.

Learning Resources	**Text Books:** 1. Non-conventional Machining by P. K. Mishra, Narosa Publishing House. 2. Non-traditional Manufacturing by G. F. Benedict, Marcel Dekkar Inc. 3. Modern Machining Processes by P.C. Pandey and H.S. Shan, Tata McGraw-Hill Publishing Company Limited. **Reference Books:** 1. Laser Material Processing by W.M. Steen, Springer-Verlag. 2. Production Technology, HMT, Tata McGraw-Hill Education

6th Semester

Course Code	ME3221N	Course Name	Automobile Engineering	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	
	● The objective of this course is to provide students with fundamental and applied knowledge of various components and drives of Automobiles. ● It includes the engine, transmission system, steering system, wheels, wheel alignment, tyres, etc. ● This subject also provides a basic overview of the Electric vehicles and their types. ● This understanding will help the students to work successfully in the automotive and ancillary industry in their future career.

Module	Syllabus	Duration (class-hour)	Module Outcome
1	Introduction- Engine classification, frame, chassis and materials for construction	01	Impart basic knowledge about the vehicle and materials and process of construction.
2	Automotive electrical system- battery (Lead acid, Alkaline, Lithium ion), maintenance free battery, starter system, details of components of conventional ignition system, limitations of conventional ignition system and modern ignition system	03	Familiarization with the different components of the ignition system in vehicles.
3	Future fuels for automobiles and their effect on the engine performance	02	Develop knowledge related to the various new and future fuels for vehicles
4	Combustion chambers in Spark Ignition and Compression Ignition Engines, Concept of Swirl, Squish and Turbulence	07	Familiarization with the SI and CI engine combustion chamber
5	Injection system in Spark Ignition and Compression Ignition Engines- Limitation of Carburetors, TBI Systems, MPFI Engines and its various sub-systems	06	Develop knowledge related to injection systems for both SI and CI engines.
6	Engine friction, sources of engine friction, need for lubrication, properties of lubricants, classification of lubricants, types of lubrication systems for automobiles	04	Impart knowledge related to friction in automotive engines and methods to reduce the same.
7	Heat transfer in engines, engine cooling system- need, types and components	04	Study different aspects of engine heat transfer and practical methods to cool the engine.
8	Automotive Steering system-components and functions, manual and power steering	03	Familiarization with the types and components of mechanical steering system
9	Wheels, wheel alignment parameters, tyres, types of tyre construction and materials	03	Impart knowledge related to wheel alignment, tyre construction and materials
10	Vehicle transmission system- components and types of drives used	03	Study the transmission system and various drives in automobiles.
11	Introduction to Hybrid and Electric Vehicles, basics of power and energy management of electric vehicles.	04	Develop basic knowledge of hybrid and electric vehicles.
12	Modern terminologies used in automobiles like ASFS, APDV, ATFT, CVT, ABS.	02	Getting acquainted with various terminologies in modern automobiles.
	Total	**42**	

Course Outcome	
	● From this course, students will develop a basic understanding of the different components and drives of a vehicle. ● This understanding will help the students to develop an aptitude in the various systems of a complete automobile. ● The knowledge can help the students to work successfully in the automotive and ancillary industry in their future career.

Learning Resources	**Text books:** 1. Automobile Engineering - K.K. Ramalingam- Scitech Publications (India) Pvt. Limited-printing 2011 2. A textbook of Automobile Engineering - R.K.Rajput – Laxmi Publications(P) Ltd. – Second edition , printing 2015 . 3. Internal Combustion Engines -V. Ganesan- Tata McGraw-Hill Education Private Limited -Fourth edition, printing 2013. 4. A textbook of Automobile Engineering I and II - P.S.Gill- S.K. Kataria and Sons-Second edition 2012, reprint 2014. **Reference Book:** 1. Automotive Mechanics by William Crouse and Donald Anglin 10th Edition Tata McGraw Hill Publishing House. 2. Automotive Engineering-An Introduction by Vincent Parese, Clanrye International Publishers, 2018. 3. Automotive Engineering Fundamentals by Richard Stone and Jeffrey K Ball, SAE International Publishers, 2004. 4. Automotive Handbook by Robert Bosch GmbH, SAE International Publishers 10th Edition, 2018. 5. Hybrid Electric Vehicles-Principles and Applications with Practical Perspectives by Chris Mi and M. Abul Masrur, Wiley, 2017. 6. Internal Combustion Engine Fundamentals – John B. Heywood- McGraw Hill, Inc.-2011. 7. Introduction to Internal Combustion Engines - Richard Stone-Palgrave Macmillan -Fourth Edition, printing 2012.

6th Semester

Course Code	ME3222N	Course Name	Power Plant Engineering	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	**CO1** : Understanding layout and criteria of site selection for power plants, classification. **CO2:** In-depth understanding of the processes and components of thermal power plants, heat & mass balance and performance analysis. ***CO3***: Power plant economics and methods of estimation of tariff. **CO4**: Knowledge of hydel and nuclear power plants. **CO5:** Understanding the environmental aspects of power plants and pollution control.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	Introduction to Thermal Power Plants, Site selection and Plant layout, Material estimation for thermal power plant, Basic thermodynamic cycles for thermal power plants	03	Basic understanding of power plants
2.	Steam power plant: heat losses and heat balance, efficiency and heat rates subcritical and supercritical steam generation, circulation and draught systems, superheaters, coal mills, air heaters, Condenser and cooling tower,	06	In-depth understanding of power plant components
3.	Water treatment, coal and ash handling systems, dust collecting devices	05	Understanding of power plant accessories
4.	Operation and control of steam power plant: Drum level, steam temperature, air flow and air pressure, combustion, deaerator and hot well level	05	Understanding of power plant control
5.	Combined cycles: series and parallel cycles, Binary vapour cycle. Integrated Gasification Combined cycle. Combined heat and power.	04	Understanding of combined cycle power plant and IGCC
6.	Emission from thermal power plants and its control, other environmental aspects of thermal power generation	04	Knowledge about environmental impacts
7.	Fluctuating loads in power plants and terminologies involved in connection to fluctuating load, Economic analysis of power plants; payback period, cost of electricity and tariffs	05	Understanding of power plant operation and economics
8.	Hydel power: Hydro electric power plant. Site selection and plant layout. Run off and measurement, Hydrograph, Flow duration curve and mass curve. Storage type power plant, pump storage plant, Mini and Micro Hydel plants. Components of hydel plants, Dam-Types, Spillways and hydraulic turbines.	05	Understanding of hydel power plant
9.	Nuclear power: Nuclear reactions, Types of reactors: PWR, BWR, PHWR, Liquid metal cooled reactor, Fast Breeder Reactor, safety and associated environmental issues	05	Understanding of nuclear power plant

	Total	**42**	

Course Outcome	In-depth understanding of different aspects of thermal power plants such as, criteria of site selection, classification and processes, components, heat & mass balance and performance analysis, Understanding of hydel and nuclear power plants, Power plant economics and methods of estimation of tariff. Environmental aspects of power plants.

Learning Resources	**Text Books** Power Plant Engineering, P.K.Nag. Power Plant Engineering, V.M. Domkundwar. **Reference Books** Power Plant Technology, W. Culp Power Plant Technology, M. El. Wakil. Handbook of Power Plant Technology, Black & Vetch (Edited)

6th Semester

Course Code	ME3223N	Course Name	Electric Vehicle Technology	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			Data Book / Codes/Standards	Nil

Course Objectives	The objective of the course is to provide interdisciplinary knowledge required for understanding the functional and deign aspects of Electric Vehicle.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	Introduction and overview of the Electric Vehicle (EV), Types of Electric Vehicles with their merits, Hybrid EV	05	What is meant by electric and hybrid vehicle, and classification.
II	Challenges and Opportunities, Comparison of ICE and EV	05	Comparison of IC engine and EV: Performance, safety and economic aspects.
III	Vehicle Subsystems	03	EV subsystems and their functions
IV	Force on moving vehicle, Power and Torque , Concept of Drive cycle	07	Vehicle dynamics , Power transmission and drive cycle in EVS
V	Energy consumption in EV	02	An estimation of power consumption of EV under different operating condition. Energy consumption.
VI	Introduction to EV battery, battery parameters, BMS, Lithium ion battery, SoS and SoH estimation	06	Different types of batteries used in EVs, Battery health and state of charge, their significance.
VII	Lithium ion battery	03	Li -ion Battery chemistry in brief. Advantage & challenges
VIII	Battery pack development and design	04	Different approaches of battery pack design and development.
IX	EV motors and controllers, EV Chargers	05	Theoretical description of EV motors, controllers and EV Charges.
	Total	**40**	

Course Outcome	Students will gain a broad overview of EV Technology. The knowledge will be helpful for budding engineers aspiring to pursue careers in modern automotive engineering. Also, the course will provide ground knowledge to pursue research in EV technology.

Learning Resources	1. Electric Vehicles Theory and Design, Yiqing Yuan, SAE International 2. Electric Vehicle Technology Explained, James Larminie, John Lowry, 2nd Edition, Wiley-Blackwell 3. Electric and Hybrid Vehicles, Iqbal Husain, 3rd Edition, CRC Press

6th Semester

Course Code	ME3224N	Course Name	Introduction to Biomechanics	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	Engineering Mechanics; Strength of Materials	Co-requisite Courses	NIL	Progressive Courses	Nil
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards			Nil

Course Objectives	The goal of the course is to introduce the fundamental concepts of engineering principles to solve problems in the domain of medicine and biology. It aims to equip students to apply the knowledge of engineering mechanics and engineering design to the human body, particularly in orthopaedics. The major focus is to make students understand the mechanics of the musculoskeletal system, anatomy and biomechanics of bones and joints, and biomechanics and biotribology of orthopaedic implants.

Module	Syllabus	Duration (class-hour)	Module Outcome
Introduction	Basic terminologies, applications, and review of Mechanical Engineering concepts related to Biomechanics	03	Students should be able to understand the basic terminology, identify application areas and consolidate their understanding of the basic mechanical engineering concepts behind
Musculoskeletal system	Musculoskeletal anatomy, function of the human musculoskeletal system, composition and structure of hard tissues and soft tissues	07	Students should be able to understand the structure and functions of the biological tissues and musculoskeletal system
Mechanical properties	Mechanical properties and biomechanical behaviour of hard- and soft-tissues, bone adaptation, viscoelasticity and anisotropy of bone	07	Students should be able to understand the mechanical properties and biomechanical behaviour of biological tissues
Basic biomechanics of human joints	Structure, range of motions and musculoskeletal model of forces for human joints (e.g. hip, knee, and spine).	09	Students should be able to understand the basic biomechanics of natural joints in the human body and apply the concepts to solve problems related to the force analysis of the joints
Basic biomechanics of orthopaedic implants	Biomaterials for orthopaedic implants, design considerations of artificial joints (e.g. hip, knee, and spine), failure mechanisms, computational and experimental approaches for analysis of implants	09	Students should be able to understand and analyse the major steps of the orthopaedic implant design process. Also, evaluate the relative importance of various design parameters.
Bio-Tribology	Bio-Tribology of natural and implanted joints, wear and lubrication	05	Students should be able to understand the tribological behavior of natural and implanted joints and apply the concepts in the design process.
	Total	**40**	

Course Outcome	At the end of the course, students should be able to 1. Understand the basic concepts of engineering principles used in solving problems in orthopedics 2. Understand the basic anatomy and biomechanics of bones and joints, and the mechanical properties of biological tissues. 3. Apply the concepts learned to solve problems in the field of orthopedic biomechanics 4. Analyze the design process of orthopedic implants 5. Evaluate the relative importance of various design considerations of orthopedic implants 6. Develop virtual/physical models of orthopedic reconstructions by assembling various information

Learning Resources	**Text Books** 1. Basic Biomechanics of the Musculoskeletal System, 4th Edition, M Nordin and VH Frankel, Lippincott Williams and Wilkins, 2012. 2. Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation. 4th Edition, N Ozkaya, D Leger, D Goldsheyder, M Nordin, Springer, 2017. 3. Biomechanics of Joints and Implants: Concepts to Applications, 1st Edition, S Gupta,CebyMS, B Pal, S Chanda, K Mukherjee, Springer Nature, 2025 **Reference Books** 5. Biomechanics - Mechanical Properties of Living Tissue, YC Fung, Springer Verlag, 1993. 6. Fundamentals of Biomechanics, 2nd Edition, D Knudson, Springer, 2017.

6th Semester

Course Code	ME3225N	Course Name	Control Systems Engineering	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	1. To teach fundamentals of control system engineering 2. To teach how fundamental theories can be applied to control mechanical systems 3. To teach how different controllers can be designed and implemented for different objectives 4. To teach how and when to choose linear and nonlinear control 5. To teach simulation of control systems

Module	Topics	Duration (class-hour)	Module Outcome
Introduction	Closed-loop and Open-loop control Objectives of Control systems Examples of control systems Laplace Transform	5	Basic understanding of architectures and objectives of control system design
Modelling of Control Systems	Frequency domain modelling – Transfer function/Transfer Matrix Concept of Poles and Zeros Block Diagram Time Domain Modelling – State-space representation	8	Learning different methods of modelling Linear Time-invariant control systems
Response Analysis	Time-domain and Frequency-domain response of first, second and higher order systems	6	Learning to compute response of linear control systems
Characteristics of control systems	Sensitivity, Disturbance/Noise rejection, Steady-state accuracy, Stability analysis	7	Learning fundamentals characteristics of control systems
Design of controller	Pole-placement, PID, Internal Model Controller, LQR	6	Learning general rules of designing controllers
Controller Design for CNC and Robotic Devices	PID Control for CNC and Robotic Manipulator	4	Learning how to design controllers for important mechatronic systems
Vibration Control	Active Vibration Control	4	Learning control of vibration of mechanical systems
Total		**40**	

Course Outcome	1. Students will learn the basic objectives of control systems with examples 2. Students will be able to design controller algorithms for various objectives, especially for mechanical systems 3. Students will be able to simulate designed controller under different test conditions 4. Overall students will have moderate exposure to Mechatronic systems

Learning Resources	**Text Books:** 1. Control system Engineering – N. S. Nise , Wiley International Edition. Latest edition 2. Principles of Passive and Active Vibration Control – A. K. Mallik and S. Chatterjee, Affiliated East-West Press, New Delhi

6th Semester

Course Code	ME3226N	Course Name	Robotics	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	To impart knowledge about the engineering aspects of Robots, Robotics system, control, sensors, programming and their application in the industries

Module	Syllabus	Duration (class-hour)	Module outcome
1	Introduction: Definition, Law of Robotics, Anatomy of a Robot, Degree of Freedom, Robot Classifications, Geometric Configurations, Robot Specifications.	2	Basic idea about robot and robotics
2	Robot Arm Kinematics: Rigid Body Rotation: Rotation Matrix, Axis-angle or Rodrigues' Rotation Formula, Successive Rotations, Euler Angles. Forward Kinematics: Homogeneous Transformation, Representation of Joints and Link, Denavit- Hartenberg Parameters. Inverse Kinematics: Solvability and Solution Techniques.	10	Impart knowledge about robot kinematics
3	Differential Motion and Velocity: Differential Motions of Frames and Robot Joints, Robot Jacobian, Inverse Differential Kinematics.	4	Impart Knowledge about differential motion
4	Robot Dynamics: Generalized Coordinates, Configuration Space, Holonomic and Non-holonomic constraints, Virtual Work, Lagrange's Equation, Kinetic Energy of a Rigid Body, Kinetic Energy for an n-Link Robot, Equation of Motion for an n-Link, Some Examples.	12	Impart knowledge about robot dynamics
5	Robotic Vision System: Process of Imaging: Architecture of Vision system, Image Acquisition. Image Digitization and Storage. Image Processing and Analysis: Data reduction, Segmentation, Feature extraction and Object recognition.	5	Impart knowledge about robot vision system
6	Trajectory Generation: Joint Space Schemes: Polynomial Trajectories. Cartesian Space Scheme: Straight Line Path, Circular Path.	4	Understand various trajectory generation techniques
7	Robot Programming and Languages: Methods of Robot Programming: Lead through Programming Methods, Textual Robot Languages. Elements and Functions of Robot Language, Variable Assembly Language (VAL).	5	Learn about robot programming languages
	TOTAL	**42**	

Course Outcome	Students will be able to: 1. Familiarize the Basics of robots Control system, kinematics and dynamics, programming techniques. 2. To familiarize the end effectors, Sensor technology and Industrial application of robot.

Learning Resources	**Text book** 1. S R Deb, Robotics technology and flexible automation, McGraw Hill publishing companylimited, New Delhi, 1994. **Reference book:** 1. R. K. Mittal and I. J. Nagrath, Robotics and Control, Tata McGraw-Hill, New Delhi, 2007. 2. M. W. Spong, S. Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley, New York, 2005. 3. T. C. Chang, R. A. Wysk, H. P. Wang, Computer aided Manufacturing, Pearson Prentice Hall, 2006. 4. S. B. Niku, Introduction to Robotics: Analysis, Control, Applications, Wiley, New York, 2011. 5. K. S. Fu, C. S. G. Lee and R. Gonzalez, Robotics: Control, Sensing, Vision and Intelligence, Tata McGraw-Hill Education, 1987. 6. M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, Industrial Robotics: Technology, Programming and Applications, Tata McGraw-Hill, New Delhi, 2008.

6th Semester

Course Code	ME3227N	Course Name	Manufacturing Automation	Course Category	OE3	L	T	P
						3	0	0

Pre-requisite Courses	*Manufacturing Technology*	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		*Mechanical Engineering*		**Data Book / Codes/Standards**	Nil

Course Objectives	The goal of the course is to provide students a fundamental understanding of the manufacturing automation employed in industries. Characterizations of the computer integrated manufacturing system and the flexible manufacturing system are addressed. Emphasis is given on CNC programming languages, machining centre, automated material handling systems, and gear hobbing operation.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	An introduction on Manufacturing Automation. Review of the development of machine tools. An introduction on the application of CNC programming on automation.	06	- Understand basic concepts of automation used in industries. - Learn CNC programming languages for general machining operations.
II	Capstan and Turret lathe. Single-spindle and multi-spindle automatic lathes. Machining centre.	10	- Learn about different lathes used for bulk production. - Learn about mechanisms employed in Capstan and Turret lathe.
III	Gear Hobbing: Different types of gear manufacturing processes, their advantages, limitations and comparison, principle of spur and helical gear hobbing, characteristics features, kinematics of gear hobbing operation, numerical problems on gear hobbing.	12	- Learn about gear hobbing mechanisms. - Understand about kinematics of gear hobbing operation with numerical problems
IV	Computer Integrated Manufacturing (CIM) and Flexible Manufacturing Systems (FMS): Definitions, characteristic features, various components, classification of manufacturing system, different configuration, typical layout of FMS, automated storage and material handling system, comparison between conventional and automated material handling system, a brief introduction on conveyor, pellet, automated guided vehicle system and industrial robot and their specific applications, application of FMS in manufacturing, numerical problems on FMS.	14	- Conceptualize about CIMS. - Understand FMS and its utilization in industries. - Learn about automated material handling systems applied nowadays in industries. - Learn about automated storage and retrieval system. - Learn about different components of automated material handling system.
	Total	**42**	

Course Outcome	At the end of the course, students should be able to 1. Understand basic aspects of the manufacturing automation. 2. Understand about the computer integrated manufacturing system and the flexible manufacturing system employed nowadays by industries. 3. Employ concepts of automated material handling systems and automated storage and retrieval systems. 4. Understand about computer aided process planning employed by industries. 5. Write CNC programming language for general machining operations like turning, milling and drilling. 6. Learn about different machining tools used for bulk production like Capstan and Turret late, gear hobbing mechanism, *etc*.

Learning Resources	**Text Book** 1. Principle of Machine Tools by G. C. Sen and A. Bhattacharya, New central book agency (P) limited. 2. Automation, Production systems and Computer-integrated manufacturing by M. P. Groover, Prentice Hall of India Pvt. Ltd. **Reference Books:** 1. Computer Aided Manufacturing – T.C. Chang, R.AWysk, , H.P.Wang 2. Computer Integrated Design and Manufacturing - D.D. Bedworth, M.R. Henderson, P.M.Wolfe ; Mc Graw Hill Inc. 3. Introduction to Robotics : S.K. Saha, Tata Mc Graw Hill CAD/CAM Principles and applications : P.N. Rao ; Tata Mc Graw Hill

7th Semester

Course Code	ME4101N	Course Name	Internal Combustion Engines and Jet Propulsion	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	• The objective of this course is to provide students with fundamental and applied knowledge of internal combustion engines and jet propulsion systems. • It aims to develop a comprehensive understanding of the thermodynamic cycles, combustion processes, fuel systems and performance parameters associated with SI and CI engines. • The course also introduces the operating principles of gas turbines and various jet propulsion systems. • Emphasis is placed on real engine behavior, emission control and fuels, preparing students for practical problem-solving in automotive and related industries.

Module	Syllabus	Duration (class-hour)	Module Outcome
1	Basic engine nomenclature and classification, 2 stroke and 4 stroke engine, Actual cycles, valve timing diagram for 2 stroke and 4 stroke SI as well as CI engines, basics of materials and processes used to manufacture engine components.	04	❖ Understand and differentiate between 2-stroke and 4-stroke SI and CI engines, including their nomenclature, classification, actual working cycles and valve timing diagrams. ❖ Gain basic knowledge of materials and manufacturing processes used in the construction of key engine components.
2	Carburetor: Simple carburetor, its working, mixture requirement of a Spark Ignition (SI) engine, derivation of air fuel ratio for simple carburetor, complete carburetor with attachments, limitation of carburetor basics of petrol injection, Types of fuel injection in SI and Compression Ignition (CI) engines	07	❖ Explain the working principles and limitations of a simple and complete carburetor, including air-fuel ratio derivation and mixture requirements of SI engines. ❖ Understand the fundamentals of fuel injection systems in both SI and CI engines, including types and basic concepts of petrol injection.
3	Ignition system basic principles: Battery and Magneto ignition system, working principle and operation, limitations of conventional breaker operated ignition system, introduction to electronic ignition system	06	❖ Understand the basic principles, working and limitations of conventional ignition systems, including battery and magneto ignition systems. ❖ Gain introductory knowledge of electronic ignition systems and their advantages over conventional breaker-operated systems.

4	Combustion in SI and CI engines, stages of combustion, factors influencing the combustion phenomenon, abnormal combustion or detonation/knocking, factors responsible for normal combustion, types of combustion chamber	05	❖ Analyse the stages and influencing factors of combustion in SI and CI engines, including the causes and effects of abnormal combustion such as knocking or detonation. ❖ Understand the characteristics of normal combustion and various types of combustion chambers used to optimize engine performance and reduce knocking.
5	Fuels and rating of fuels for internal combustion engine. Fuel used in the jet engines. Basic overview of alternative fuels, Environmental pollution from vehicles, its measurement and control	04	❖ Understand the properties and rating of fuels used in internal combustion and jet engines, along with a basic overview of alternative fuels. ❖ Analyse the sources of vehicle emissions, their environmental impact and methods for pollution measurement and control.
6	Testing and performance characteristics of internal combustion engine and heat balance, engine performance parameters, indicator card	07	❖ Evaluate the performance characteristics of internal combustion engines through testing, including heat balance and key performance parameters. ❖ Interpret indicator diagrams (indicator cards) to analyse engine efficiency, combustion behaviour and operational performance.
7	Supercharging and Turbo-charging, Their effect on the engine performance	03	❖ Understand the principles and working mechanisms of supercharging and turbocharging in internal combustion engines. ❖ Analyse the impact of supercharging and turbocharging on engine performance parameters such as power output, efficiency and fuel consumption.
8	Basics of jet propulsion system, Air Breathing engines: Turboprop, Turbojet, Ramjet, Pulse jet. Basics of Rocket and types of propellants used in the rockets	06	❖ Understand the fundamental principles of jet propulsion systems and air-breathing engines, including turboprop, turbojet, ramjet, and pulse jet engines. ❖ Gain basic knowledge of rocket propulsion systems and the types of propellants used in rocket engines.
	Total	**42**	

Course Outcome	• From this course, students will be able to understand the working principles of Spark Ignition and Compression Ignition engines. • They can analyze thermodynamic cycles related to internal combustion engines and jet propulsion systems. • They can evaluate engine performance parameters along with the component functions. • The students can apply the theoretical and practical knowledge to solve engineering problems related to power and propulsion systems.

Learning Resources	**Text books: (to change)** 1. Internal Combustion Engines-V. Ganesan-Tata McGraw-Hill Education Private Limited-Fourth edition, printing 2013. 2. Internal Combustion Engines by M.L. Mathur and R.P. Sharma-Dhanpat Rai Publications-printing 2016. 3. A course in Internal Combustion Enginesby V.M. Domkundwar and A.V. Domkundwar-Dhanpat Rai and Co.-printing 2013. 4. Gas Turbines-V. Ganesan-Tata McGraw-Hill Education Private Limited-Third edition, printing 2010. **Reference Book:** 1. Fundamentals of Internal Combustion Engines–Paul W Gill and James H Smith-Oxford and Ibh Publishing Company Pvt. Limited, printing 2007. 2. Internal Combustion Engines Fundamentals-John B. Heywood-McGraw Hill, Inc.-2011 3. Introduction to Internal Combustion Engines-Richard Stone-Palgrave Macmillan-Fourth Edition, printing 2012. 4. Gas Turbine Theory-H I H Sarvana mutto, H.Cohen, G F C Rogers-Person (India) Private Limited-Fifteenth Edition printing 2016.

7th Semester

Course Code	ME4102N	Course Name	Industrial Engineering and Operations Research	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	To impart introductory knowledge on Industrial Engineering, concept of Productivity and work study. To make familiar about facility layout and planning, systems of production planning and control and techniques of inventory management. Formulate the real life problem and application of various Operations Research tools

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	Introduction to (a) Industrial Engineering and (b) Operation Management with historical references.	02	Importance and application of IE and OR
2.	Plant layout, Production planning and control,	02	Knowledge about various plant layout
3.	Forecasting models.	03	Knowledge about forecasting module
4.	Inventory control: Deterministic Inventory control, Safety stock inventory control system, Materials Requirement Planning, Aggregate Production Planning.	04	Learn various inventory control techniques
5.	Work study, Motion study, Replacement analysis, Value engineering,	03	Understanding about work study and value engineering
6.	Statistical Quality Control, Maintenance and reliability.	03	Learn about SQC
7.	Scheduling and sequencing, Simple queuing models.	03	Impart knowledge about queuing model
8.	Incentive plans, Break-even analysis, Project Management.	02	Impart knowledge about project management
9.	**Linear programming problem**: Introduction to linear programming, linear programming models, algorithms, minimization and maximization problems, Simplex and Big-M methods, some special cases of LPP	05	Understand LPP application
10.	**Dual-simplex method:** Concept of duality, primal and dual problem, algorithm, problems on dual-simplex methods.	04	Understand Dual Simplex method for real life problem
11.	**Transportation problem:** Algorithm, North-west corner rule, Vogel's approximation method, U-V method, degeneracy, some special cases on transportation problems	03	Learn transportation model
12.	**Assignment problem:** Introduction**,** Mathematical Formulation of the Problem, Hungarian Method Algorithm, Travelling Salesman Problem	02	Learn assignment model approach
13.	**Network models:** Concept of CPM and PERT, problems on Network models.	03	Impart knowledge about network model techniques

14.	**Industry 4.0 and Smart Factory**	02	
	TOTAL	**41**	

Course Outcome	At the end of the course, the student will be able to: 1. Understand the concepts of Industrial Engineering. 2. Explain production systems and their characteristics. 3. Understand the role of productivity in streamlining a production system. 4. Describe different aspects of work system design and facilities design pertinent to manufacturing industries 5. Apply forecasting and scheduling techniques to production systems. 6. Apply the inventory management tools in managing inventory 7. Formulate mathematical model of a real life problem for optimization and apply various Operations Research techniques for those problem effectively.

Learning Resources	**Text book** 1. Industrial Engineering and Management by Dr.O.P.Khanna 2. Production Systems: Planning, Analysis, and Control by James L. Riggs, John Willey and Sons. 3. Operations Research - by Hamdy A. Taha, Prentice-Hall of India Private Limited **Reference book:** 1. Operations Research Principles and Practice – by **A. Ravindran, Don T.Phillips and James J. Solberg**- John Wiley & Sons. 2. Quantitative Techniques in Management – by **N.D.Vora** – Tata McGraw- Hill Publishing Company Limited – New Delhi 3. **AmitavaMitra,**Findamentals of Quality Control and Improvement – PHI 4. Factory and Production Management by **K.G.Lockyer** – Publisher – The English Language Book Society and Pitman Publishing. 5. Production and Operations Management by **S.N.Chary** - Tata McGraw – Hill Publishing Company Limited – New Delhi 6. Production systems : planning, analysis, and control / [by] **James L**. **Riggs**. Author. Riggs, James L. Published. New York : Wiley, [1970]. 7. Introduction to operations research / **Frederick S. Hillier, Gerald J. Lieberman**.

7th Semester

Course Code	ME 4121N	Course Name	Energy Storage Technology	Course Category	OE4	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	
	• The objective of this course is to provide students with fundamental and applied knowledge of various energy storage technologies. • It aims to develop a comprehensive understanding of both the traditional methods of energy storage along with the modern state of the art technologies. • The renewable energy systems are gaining more importance day by day owing to their eco-friendly nature. • Various methodologies for energy storage, especially renewable energy, so that their availability is ensured all the time is discussed in this subject.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	Need for energy storage, Basics of Electrochemical energy storage system, Battery, classification: Lead Acid, Nickel Cadmium, Sodium Sulphur and Lithium ion Battery; Battery testing, Battery capacity, Charging-Discharging cycle, Capacitor: ultra and super capacitors.	06	Understanding the types of electrical energy storage devices.
2.	Compressed air storage (CAS) plants, types and applications	03	To acquire knowledge regarding the compressed air storage plants and their applications.
3.	Superconducting Magnetic Energy Storage (SMES)	02	To learn the basics of SMES systems.
4.	Mechanical Energy storage device- flywheel and its applications.	02	To familiarize with the different mechanical energy storage systems
5.	Site selection of hydel plants, Hydrograpgh and Flow Duration Curve, Mass curve, Storage type hydel plants, Run off river plants, Dams, Types of dams. Spillways and types	04	Learn the basics of site selection of different types of hydel plant along with the components.
6.	Pump storage plants, types, applications, advantages and limitations..	03	In-depth knowledge of pump storage plants.
7.	Hydrogen production and storage: Different methods of hydrogen production; chemical, thermo-chemical, photochemical, electro-chemical; electrolyzer and fuel cell. Fuel cell types and thermodynamics, efficiency and voltage. Reversible fuel cell; Thermal splitting of water	06	Understanding the methods of hydrogen storage and fuel cells.
8.	Thermal Energy Storage System- Long and Short duration storage, Sensible heat storage system, Latent heat storage system, Thermo-chemical energy storage. Applications of thermal storage system.	02	Understanding the basics of types of thermal energy storage system
9.	Concept of solar Pond and types. Basics of Thermo-electric generator. Concept of Heat Pipes and its applications	03	Develop the concept of the solar pond, types and applications
10.	Chemical Energy storage- Bio-fuels and Hydrated Salts, Accumulators with internal and external storage. Graphene based composites for electrochemical energy storage	05	Develop the knowledge of chemical energy storage systems
11.	Economics of the Energy Storage, Payback period and Life cycle Savings calculation, Power Tariff, Special considerations for energy storage in power plant applications	06	To familiarize with the terminologies related to the economics of energy storage for various applications.
	Total	**42**	

Course Outcome	• From this course, the students will be able to understand the working principles of various forms of storage of energy. • This is very important for ensuring the energy availability round the clock even for the remote areas, where extension of the conventional grid electricity is a challenge. • The students will gain the ability to apply theoretical and practical knowledge to solve engineering problems related to energy storage for the various real life applications.

Learning Resources	**Text books:** 1. Energy Storage Systems by David Elliott, IOP Publishing Ltd. Bristol, UK, 2017.ISBN 978-0-7503-1531-9 (ebook). 2. Solar Energy: Principles of Thermal Collection and Storage by S. P. Sukhatme and J.K.Nayak, Tata Mc Graw-Hill Publishing Company Limited, New Delhi. **Reference Books:** 1. Fuel Cell Handbook (Seventh Edition) US Department of Energy by EG & G Technical Services, Inc. November 2004. 2. Solar Engineering of Thermal Processes by John A Duffie and William A Beckman, John Wiley & Sons, Inc. First published April 2013, Print ISBN:9780470873663 |Online ISBN:9781118671603. 3. Storing Energy Ist Edition by Trevor Letcher, Imprint Elsevier, 2016, Hardcover ISBN: 9780128034408,eBook ISBN: 9780128034491.

7th Semester

Course Code	ME4122N	Course Name	Solar & Wind Energy	Course Category	OE4	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	**CO1** : Overview of solar and wind as renewable energy sources **CO2:** In-depth understanding of solar and surface angles and estimating solar radiation. ***CO3****:* Understanding of different types of solar thermal collectors, their performances and applications **CO4**: Understanding of solar photovoltaic cells, modules and their performances **CO5:** Understanding of wind energy potential, different types of conversion systems and their performance estimation **CO6**: Understanding of economic aspects and environmental impacts of solar and wind energy

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	Introduction, Sun as the source of radiation, Solar constant, Spectral distribution of extraterrestrial radiation, Solar radiation geometry: Latitude of location, Declination, Hour angle, Slope of surface, Altitude angle, Zenith angle, Solar azimuth angle, Local solar time, Equation of time.	04	Basic understanding solar energy and solar geometry
2.	Classification and estimation of solar radiation: Beam, Diffuse, Global radiations; Angle of incidence on horizontal surface, Angle of incidence on inclined surface, Computation of solar radiation on tilted surface. Average daily radiation, Hourly global and diffuse radiation, Measurement of direct and diffuse radiations.	06	In-depth understanding of solar and surface angles and estimating solar radiation
3.	Basic overview of solar collectors, Flat Plate Collector and its Performance Analysis. Concentrating collectors of different types	04	Understanding of different types of solar collectors
4.	Solar thermal applications: Solar water heating, Solar cooking, Solar desalination, Solar drying of food products, Solar power generation, Solar energy for industrial process heat, Solar passive heating of buildings, Solar greenhouses, Solar refrigeration.	06	Understanding of application of solar thermal energy
5.	Solar photovoltaic: Fundamentals of photovoltaic conversion, Performance of solar cells, Efficiency and Fill Factor. Equivalent circuit for solar cells, Solar modules and array, Standalone, Grid independent, Grid interactive systems.	06	Understanding of principles of photovoltaic conversion and performance analysis
6.	Wind Energy, estimation of wind energy potential; wind energy density, factors affecting wind energy, Applications of Wind Energy, Environmental Aspects.	04	Basic understanding wind energy and its influencing factors
7	Conversion System, Classification of WEC systems, Advantages and Disadvantages of different WECS, Basic analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind- machines, Generating Systems,	04	Understanding of different types of conversion systems and their performance estimation

8.	Economics of solar and wind energy conversion, environmental benefits, advantages and limitations.	04	Understanding of economic aspects and environmental impacts
	Total:	**42**	

Course Outcome	In-depth understanding of solar and wind energy conversion systems, their performance estimation. Understanding of the economics and environmental aspects of solar and wind energy.

Learning Resources	**Text Books:** 1. Solar Energy Fundamentals and Applications by H. P. Garg and J. Prakash, Tata Mc Graw-Hill Publishing Company Limited. 2. Solar Energy Fundamentals, Design, Modelling and Applications by G. N. Tiwari, Narosa Publishing House. 3. Wind energy Conversion Systems – Freris L.L. (Prentice Hall1990). 4. Wind Energy Systems – G.L. Johnson (Prentice Hall, 1985) **Reference Books:** 1. Solar Energy: Principles of Thermal Collection and Storage by S. P. Sukhatme and J.K.Nayak, Tata Mc Graw-Hill Publishing Company Limited. 2. Solar Engineering of Thermal Processes by John A. Duffie and William A. Beckman, John Wiley and Sons, Inc. 3. Wind Energy Explained – J.F.Manwell, J.G. McGowan and A.L. Rogers (John Wiley & Sons Ltd.)

7th Semester

Course Code	ME4123N	Course Name	CAD/CAM	Course Category	OE4	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	CAD to CAM is a special subject as it requires in depth knowledge of CAD (design) and CAM (CNC machining). Detail generic knowledge will be imparted to the students on the concepts of CAD modelling and its mathematical background for creating real-life products. Toolpath design is an integral part for CNC machining for producing a component which is created by CAD modelling. Students will be able to combine these two aspects.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	**Basic concepts of CAD and CAM and their application:** Common and industrial applications; Different CAD software: their main features; Concepts of CAM: main components of CNC machines: hardware and software; Integration of CAD and CAM: their real benefit. Design for manufacturing concepts;	6	The students will able to gain the comprehensive idea and knowledge about CNC machines including hardware and software.
2.	**CAD :** Mathematical background of CAD : geometric transformation; wireframe and solid modelling; non-parametric and parametric representation of curves and surfaces; tangent, normal and curvature; Simple assembly design; web-based modelling system;	10	The students will able to perform geometric transforms utilizing parametric and non-parametric representation.
3.	**CAM :** Components and architecture of a CNC machine; CNC, DNC and FMS; Features of CNC that improve productivity and precision; CNC machine programming : G&M code; Some advanced programming for CNC Lathe, CNC Milling and CNC Wire-EDM.	8	The students will able to improve the CNC machine programming for CNC lathe, CNC milling and CNC Wire-cut EDM.
4.	**CAD,CAM integration**: Data Standards for data exchange : IGES, STEP, CALS, DXF, STL; Generation of automatic machining code from CAD data; Toolpath design and verification; Toolpath simulation; Steps required in CAD modelling for smooth generation of automatic machining code; Features of CAD/CAM software like Master-CAM, ELCAM (for WEDM).	6	The students will able to learn the automatic machining code generation from CAD data utilizing various CAD/CAM softwares.

5.	**CAD/CAM control strategies** : Design a component for CNC manufacturing; CNC toolpath design; Strategies for increasing productivity; Adaptive control of CNC machining.	6	The students will able to design various components for CNC manufacturing.
	TOTAL	**36**	

Course Outcome	From this course, the students will be able to produce the machining code automatically for a real-life component, which is modelled on CAD. They will also have a clear understanding on the principles of design for CNC manufacturing. Components will be designed on CAD in such a way so that toolpath generation will be easier for its manufacturing. They will also gain knowledge on the time-saving strategies for increasing productivity for both the aspects: CAD and CAM.

Learning Resources	**Text books: (to change)** 1. Computer-Aided Manufacturing (Second edition) – TIEN-CHIEN CHANG, RICHARD A. WYSK, HSU-PIN WANG: Prentice Hall International Inc. 2. Mastering CAD/CAM, Ibrahim Zeid ; Tata McGraw-Hill, New Delhi 3. Computer Control of Manufacturing Systems : Y Koren : McGraw Hill Education (India) Pvt Ltd, New Delhi **Reference Book:** 1. Principles of CAD/CAM/CAE systems, Kunwoo Lee, Addison Wesley, 1999. 2. CNC Machining Handbook: Building, Programming and Implementation - Alan Overby; McGraw Hill Pub. 3. Metal Cutting Principles – M.C. Shaw, Oxford University Press, Indian Addition, Kolkata**.** 4. CADCAM: principles, practice and manufacturing management, Chris Macmahon and Jimmie Browne; Addison Wesley

7th Semester

Course Code	ME4124N	Course Name	Finite Element Methods for Engineering	Course Category	OE4	L	T	P
						3	0	0

Pre-requisite Courses	1. Mathematics I (MA-1101) 2. Mathematics II (MA-1201) 3. Strength of Materials (AM-2101) 4. Numerical Methods in Engineering (ME-2102) 5. Heat Transfer (ME-3101) or, equivalent subjects	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering			**Data Book / Codes / Standards**	Nil

Course Objective	1) To make the students able to differentiate and idealize the systems 2) To make the students able to formulate the system's governing equations under different equilibrium and stability conditions, and identify the initial and boundary conditions 3) To make the students able to solve the governing equations for the discrete systems 4) To make the students able to solve the governing equations using different numerical methods of solving Initial/Boundary Value Problems for continuous systems 5) To make the students acquainted with the Finite Element Formulation of 1D Boundary Value Problems and 2D Scalar Field Problems 6) To make the students able to formulate and solve 2D thermomechanical stress analysis problems using Finite Element Formulations

Module	Syllabus	Duration (class-hour)	Module Outcome
Introduction	Introduction to Numerical Methods, Difference between Finite Difference (FD) and Finite Element (FE) Methods. Basic steps of the Finite Element Method. Versatility of FEM and its use in different applications. Review of matrix theory and numerical solution of linear algebraic equations.	3	After successful completion of the Module, the students will be able to UNDERSTAND the systems, their idealization, working principle of Finite Element Method and its differences with other numerical methods. **(CO1)**
Direct Stiffness Method	FE solution of assemblage of linear springs arranged in 1D by direct stiffness method: Discretization, derivation of element equations, assembly rule and imposition of boundary conditions. Solution nodal displacements and calculation of support reactions. Problems.	3	After successful completion of the module, the students will be able to ANALYSE the Discrete Systems. **(CO2)**
	Extension of direct stiffness method from 1D to 2D: Analysis of Plane truss. Derivation of element equations, assembly rule and imposition of BC. Solution for displacements, member forces and support reactions. Special case of inclined roller supports. Problems on plane truss.	5	
Continuous Systems	Approximate solution of boundary value problems involving ODE by the weighted residual method. Weighted integral statement. Point collocation, Least-square, Rayleigh-Ritz and Galerkin's procedure. Weak form: primary variables, secondary variables, essential BC,	5	After successful completion of the module, the students will be able to ANALYSE the continuous systems' governing equations. **(CO3)**

	natural BC. Advantages of weak form over strong form. Examples.		
	Solution of boundary value scalar field problems (such as heat transfer with conduction, surface convection in presence of heat generation) depicted by ODE in 1-D. Deriving Shape functions of a 1-D linear and higher order elements, Natural coordinates. Derivation of equation of a finite element from its weak form. Assembly, imposition of BC and solution for primary and secondary variables (PV and SV). Problems.	5	
Finite Element Formulations	Review of Euler-Bernoulli beam equations. FE formulation of 1D beam problem governed by Euler-Bernoulli equation: Weak form, Galerkin's procedure. Introduction to C^1 continuous elements. Isoparametric and sub-parametric formulation, Derivation of element equations, Assembly, Examples under general loading with different cases of supports. Introduction to Frame elements.	5	After successful completion of the module, the students will be able to ANALYSE the 1D and 2D problems by Finite Element formulation. **(CO4)**
	FE formulation of 2D scalar field problem, Weak form, Galerkin's procedure, Area coordinates, 3-node, 6-node triangular elements. Conforming and non-conforming elements while introducing 4-node and 8-node quadrilateral elements. Coordinate transformation, Jacobian, Parent and child elements. Problems involving 2-D steady state heat transfer with conduction, surface and edge convection, and heat generation, Problems on torsion of non-circular shafts.	8	
Stress Analysis Problems	Plane stress and plane strain type in 2D. Review of equilibrium equation, stress-strain and strain-displacement relation. Introduction to variational formulation, Meaning and derivation of functional in standard form. Variational formulation of 2D stress analysis problems under general loading and heart transfer problems and derivation of their functional. Problems.	5	After successful completion of the module, the students will be able to ANALYSE a special class of problems where minimization of total potential is applicable. **(CO5)**
Class Test:		1	
Total:		**40**	

Course Outcome	After successful completion of the course, the students will be able to: 1) UNDERSTAND the systems, their idealization, working principle of Finite Element Method and its differences with other numerical methods. 2) ANALYSE the Discrete Systems 3) ANALYSE the Continuous Systems 4) ANALYSE the 1D and 2D Problems by Finite Element Formulations 5) ANALYSE a special class of problems where 'Minimization of Total Potential' is applicable.

Learning Resources	**Text Books:** 1. Fundamentals of Finite Element Analysis, by D. V. Hutton, Tata McGraw Hill 2. A First Course in the Finite Element Method, by D. L. Logan, Cengage Learning **Reference Books:** 1. An introduction to the Finite Element Method, by J. N. Reddy, Tata McGraw Hill 2. Introduction to Finite Elements in Engineering, T. R. Chandrupatla and A. D. Belegundu, Cambridge University Press 3. Finite Element Procedures, K. J. Bathe, Prentice Hall India 4. A First Course in Finite Elements, J. Fish and T. Belytschko, John Wiley 5. Finite Element Methods for Engineers, R. T. Fenner, Imperial College Press 6. Finite Element Analysis Theory and Programming, C. S. Krishnamoorthy, McGraw Hill

7th Semester

Course Code	ME4125N	Course Name	Additive Manufacturing	Course Category	OE4	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		Data Book / Codes/Standards	*Nil*

Course Objective	To impart knowledge about fundamental of additive manufacturing technologies, steps in additive manufacturing, process methodology, process parameters and control of various metal and non-metal additive manufacturing technologies.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & conventional machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM	06	Impart knowledge about advantages of additive manufacturing technologies
2.	**CAD for Additive Manufacturing:** CAD Data formats, Data translation, Data loss, STL format, STL conversion error, errors checking and correction algorithm, Slicing algorithms:-uniform flat layer slicing, adaptive slicing, Process-path generation: Process-path algorithms, rasterization, part Orientation and support generation.	06	Impart knowledge about preprocessing steps in additive manufacturing
3.	**Vat Photo polymerization AM Processes:** Stereo lithography (SLA), Materials, Process Modelling, SLA resin curing process, SL scan patterns, Micro-stereo lithography, Mask Projection Processes, Two-Photon vat photo polymerization, Process Benefits and Drawbacks, Applications of Vat Photo polymerization, Material Jetting and Binder Jetting AM Processes.	04	Develop knowledge about photo polymerization type process
4.	**Extrusion - Based AM Processes:** Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, BioExtrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.	04	Develop knowledge about extrusion based process
5.	**Sheet Lamination AM Processes:** Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.	04	Develop knowledge about sheet lamination type process
6	**Powder Bed Fusion AM Processes:** Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process	06	Develop knowledge about powder bed fusion type process

	Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, Selective Laser Melting (SLM)		
7	**Directed Energy Deposition AM Processes:** Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structureproperties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. Materials science for AM – Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship.	06	Develop knowledge about DED type process
8	**Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques .Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control, AM part testing & characterization	05	Impart knowledge about various post processing techniques
	TOTAL	**41**	

Course Outcome	Students will develop knowledge about the necessity, preprocessing and post processing process of additive manufacturing, fundamentals of various additive manufacturing technologies along with process control and input materials.

Learning Resources	**Text book** 1. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015. 2. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies",Springer, 2004 **Reference book:** 1. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015. 2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001. 3. RafiqNoorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

7th Semester

Course Code	ME4126N	Course Name	AI&ML Applications in Mechanical Engineering	Course Category	OE4	L	T	P
						3	0	0

Pre-requisite Courses	1. Mathematics I (MA-1101) 2. Introduction to Computing (CS-1101) 3. Mathematics II (MA-1201) 4. Mathematics III (MA-2101) 5. Numerical Methods in Engineering (ME-2102) or, equivalent subjects	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Mechanical Engineering		Data Book / Codes/Standards	Nil

Course Objective	1) To make the students understand the basic principles of Artificial Intelligence towards problem solving, inference, perception, knowledge representation, and learning. 2) To provide the students foundation in mathematical concepts related to Machine Learning 3) To equip the students to choose appropriate classification technique to perform classification, model building and evaluation 4) To make the students able to model and optimize real-life problems related to mechanical engineering using previously learned concepts

Module	Syllabus	Duration (class-hour)	Module Outcome
Artificial Intelligence	Introduction, intelligent agent (Environment, Rationality, Good Behaviour, Structure of agent), Solving problems by Search (Formulating problems, Searching for Solutions, Uninformed Search Strategies, Breadth-first search, Depth-first search, Searching with Partial Information, Informed (Heuristic) Search Strategies, Greedy best-first search, A* Search, CSP, Means-End-Analysis), ADVERSARIAL SEARCH (Games, The Mini-Max algorithm, Alpha-Beta Pruning), LOGICAL AGENTS (Knowledge-Based agents, Logic, Propositional Logic, Reasoning Patterns in Propositional Logic, Resolution, Forward and Backward chaining), FIRST ORDER LOGIC (Syntax and Semantics of First-Order Logic, Using First-Order Logic, Knowledge Engineering in First-Order Logic), UNCERTAINTY (Acting under Uncertainty, Basic Probability Notation and Axioms of Probability, Joint Distributions, Independence, Bayes' Rule, Representing Knowledge in an Uncertain Domain),	12	After successful completion of the module, the students will be able to UNDERSTAND the working principles of the intelligent logical agent and their real-life implementation.**(CO1)**

Learning Methods	Statistical Learning, Learning with Complete Data, Learning with Hidden Variables, Rote Learning, Learning by Taking Advice, Learning in Problem-solving, learning from Examples: Induction, Explanation-based Learning, Discovery, Analogy, Formal Learning Theory, Neural Net Learning and Genetic Learning. Expert Systems: Representing and Using Domain Knowledge, Expert System Shells, Explanation, Knowledge Acquisition, Lazy Lerner	6	After successful completion of the module, the students will be able to UNDERSTAND the architecture and working mechanism of the different models of machine learning.**(CO2)**
Artificial Neural Network (ANN)	Basic NN Architectures, Learning algorithms and paradigms, Learning, Single layer and multilayer perceptions, back propagation network, SOM, Radial basis Function Networks, Elman-Jordan Recurrent Neural Networks, Convolutional and Deep Neural Network and related algorithms, Applications in Thermal, Design and Manufacturing problems	5	After successful completion of the module, the students will be able to APPLY Artificial Neural Network to real problems in mechanical engineering. **(CO3)**
Fuzzy Logic System	Fuzzy Set Theory, Fuzzy Relation, Fuzzy Logic and Approximate Reasoning, Fuzzy logic system design, Applications in Thermal, Design and Manufacturing problems	4	After successful completion of the module, the students will be able to APPLY Fuzzy Logic to real problems in mechanical engineering. **(CO4)**
Optimization	Introduction, Single, Multi and Many Objective Optimization, Pareto Optimal Front, Non-linear Unconstrained and Constrained Multivariable Optimization, Multi-Variable Constrained Numerical Algorithms, Nature Inspired Optimization Techniques: Genetic algorithms (GAs), GA operators: Crossover, Mutation etc., Swarm Intelligence based techniques (Particle Swarm Optimization, Firefly algorithm, Flower pollination algorithm, Crow search algorithm etc.), Queuing models: General characteristics, Markovian queuing model, Queue discipline.	8	After successful completion of the course, the students will be able to APPLY different optimization techniques on different problems in mechanical engineering.**(CO5)**
Class Test		1	
Total Hours		**36**	

Course Outcome	After successful completion of the course, the students will be able to: 1. UNDERSTAND the working principles of the intelligent logical agent and their real-life implementation. 2. UNDERSTAND the architecture and working mechanism of the different models of machine learning. 3. APPLY Artificial Neural Network to real problems in mechanical engineering. 4. APPLY Fuzzy Logic to real problems in mechanical engineering. 5. APPLY different optimization techniques on different problems in mechanical engineering.

Learning Resources	**Text book** 1. Artificial Intelligence -A Modern Approach, Stuart Russell and Peter Norvig, Pearson Education. 2. Soft Computing: Fundamentals and Applications,DilipK. Pratihar, Alpha Science International Ltd. 3. Neural Networks: A Comprehensive Foundations, Simon Haykin, Pearson Education 4. Fuzzy Logic with Engineering Applications, Timothy. J. Ross, Wiley 5. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, Prentice Hall India 6. Multi-objective Optimization using Evolutionary Algorithms, Kalyanmoy Deb, Wiley

	Reference book 1. Artificial Intelligence, Elaine Rich, Kevin Knight andShivashankar B Nair, McGraw Hill 2. Artificial Intelligence: A New Synthesis, Nils J Nilsson, Morgan Kaufmann Publications 3. Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, Prentice Hall of India 4. Artificial Intelligence, S Kaushik, Cengage Learning 5. Artificial neural networks, B.Vegnanarayana, Prentice Hall of India 6. Neural networks in Computer intelligence, Li Min Fu, Tata McGraw Hill 7. Neural networks, James A Freeman and David M Skapura, Pearson Education 8. Uncertain Rule-Based Fuzzy Logic Systems: Introduction and New Directions, Jerry M. Mendel, Prentice Hall 9. Fuzzy Sets and Fuzzy Logic – Theory and Applications, G. J. Klir and Bo Yuan, Prentice Hall India 10. A Neuro-Fuzzy Synergism to Intelligent System, C.T. Lin and George Lee, Prentice Hall 11. Neuro Fuzzy Systems, V.K.Lamba, Laxmi Publications 12. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press 13. Genetic Algorithms in Search, Optimization and Machine Learning, David E. Goldberg, Addison Wesley

8th Semester

Course Code	ME4221N	Course Name	Computational Fluid Dynamics and Heat Transfer	Course Category	OE5	L	T	P
						3	0	0

Pre-requisite Courses	Fluid Mechanics & Heat Transfer	Co-requisite Courses	Numerical Methods in Engineering	Progressive Courses	
Course Offering Department	Mechanical Engineering			Data Book / Codes/Standards	

Course Objective	• To introduce and develop the main approaches and techniques which constitute the basis of computational fluid dynamics. • To familiarize students with the numerical implementation of these techniques and numerical schemes, so as to provide them with the means to write their own codes • To enable them to acquire the knowledge necessary for the effective utilization of commercial (CFD) packages used in research and industry • To discuss a range of modern approaches for numerical and computational fluid dynamics, with an aim to inculcate interest for further studies.

Module	Syllabus	Duration (class-hour)	Module Outcome
01	Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modelling vs Experimentation, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation	03	• Students will know the various methods by which a real-life problem may be solved. • Students will understand how all governing equations have a common form.
02	Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations	04	• Students will be aware of the different types of partial differential equations and the corresponding systems that they govern.
03	Fundamentals of Discretization: Preprocessing, Solution, Postprocessing, Finite difference method, Finite Element Method (FEM), Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness	05	• Students will be aware of the different steps in any CFD technique. • Students will be familiarized with the concept of boundary condition and its possible variations.
04	Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Composite material with position dependent thermal conductivity, Four basic rules for FV Discretization of 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary condition	05	• Students will be able to discretize governing equations for 1D diffusion problem. • Students will be able to develop their own codes to solve 1D diffusion in adherence with the different prevalent rules.

05	Discretization of Unsteady State Problems	02	• Students will be able to discretize and solve governing equations for unsteady 1D diffusion problem.
06	Consequences of time-discretization in finite discretization, Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability 4 analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Stability analysis of 2nd order hyperbolic equations: CTCS scheme	06	• Students will be aware of any given numerical scheme. • Students will be able to perform stability analysis for any given numerical scheme.
07	FVM for 2-D unsteady state diffusion problems	02	• Students will be able to discretize and solve governing equations for 2D diffusion problem.
08	Discretization of Convection-Diffusion Equations: A Finite Volume Approach: Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme	05	• Students will be aware of the solution method for convection-diffusion equation. • Students will know the different schemes applicable to the solution of the convection-diffusion equation.
09	Discretization of Navier Stokes Equations: Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm	05	• Students will be able to discretize the Navier Stokes equation. • Students will be aware of concept of staggered grid. • Students will be able to develop their own codes to solve the Navier Stokes equation.
Total		**38**	

Course Outcome	At the end of the course, students will be able to: **CO1:** Understand the concept of discretization of equations. **CO2:** Apply the numerical techniques and schemes to solve governing equations **CO3:** Evaluate the performance of systems by using available software and codes **CO4:** Create CFD codes to solve complex flow problems

Learning Resources	**Text Books:** 1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill. 2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press. 3. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor &Francis 4. H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.

8th Semester

Course Code	ME4222N	Course Name	Fatigue and Fracture Mechanics	Course Category	OE5	L	T	P
						3	0	0

Pre-requisite Courses	1. Mathematics I (MA-1101) 2. Mathematics II (MA-1201) 3. Strength of Materials (AM-2101) 4. Fundamentals of Machine Design (ME-2203) 5. or, Equivalent Courses	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	**Data Book / Codes/Standards**	ASTM E606 ASTM E399 ASTM E1820		

Course Objective	1) To make students proficient in using the more practical fatigue damage criteria for metals in machine design. 2) To make students acquainted with the concepts of fracture mechanics in engineering design for different materials under static loading conditions as a realistic alternative of classical strength-based design with large factor of safety.

Module	Syllabus	Duration (class-hour)	Module Outcome
Fatigue of Metal	Concept of Fatigue failure, High Cycle Fatigue, Low Cycle Fatigue (a) High cycle fatigue (Stress-based fatigue) - Definition of stress cycles, fatigue life and endurance limit, S - N curve and Wohler Diagram, effect of mean stress and stress ratio on fatigue life, the Soderberg, Goodman and Gerber plots, effect of notch on fatigue life, Basquin equation for stress-based fatigue life calculation, fatigue strength coefficient and fatigue strength exponent. (b) Low Cycle Fatigue (Strain-based fatigue) - Hysteresis loop, cyclic hardening and softening phenomena. Steady state loop. Masing and non-Masing loop. Cyclic stress-strain curve. Coffin-Masson equation, Fatigue ductility coefficient and fatigue ductility exponent. Total strain life curve (Morrow's equation). Mean stress correction i) Morrow's method ii) SWT (Smith Watson Topper) Method. (c) Fatigue damage accumulation and life exhaustion, Linear damage rule (Palmgren-Miner Rule), cycle counting methods	15	After successful completion of the module, the students will be able to UNDERSTAND the damage mechanisms of materials under quasi-static, time dependent and varying direction (and magnitude) loading**(CO1)** and EVALUATE the life of materials under fatigue loading conditions by considering environment and other factors.**(CO2)**
Linear Elastic Fracture Mechanics (LEFM)	(a) Theoretical Cohesive strength of Material (An Atomic View), Stress concentration effect of Flaws, Griffith Energy Balance. Energy Release Rate, Instability, R – curve (b) Crack tip stress field analysis, Stress Intensity Factor, K-dominated field, Crack tip plastic zone (Irwin model/Dugdale	15	After successful completion of the module, the students will be able to UNDERSTAND the damage mechanisms of materials under quasi-static loading **(CO1)** and EVALUATE the fracture parameters for linear elastic materials. **(CO3)**

	model), Plane stress/plane strain fracture Mechanics		
Fatigue Crack Growth	Paris Law and its modifications, over loading effect, Variable amplitude loading, Determination of FCGR Curve	4	After successful completion of the module, the students will be able to EVALUATE the fatigue crack growth rate of materials for constant and variable amplitude fatigue loading. **(CO4)**
Elastic Plastic Fracture Mechanics (EPFM)	JCont our Integral, Path independence of J-integral - Example, Crack Tip Opening Displacement (CTOD), J-Rcurve, Ductile crack growth and Instability, Tearing Modulus	5	After successful completion of the module, the students will be able to EVALUATE the fracture parameters for linear elastic materials undergoing large-scale plasticity. **(CO5)**
Class Test		1	
Total:		**40**	

Course Outcome	After successful completion of the course, the students will be able to: 1) UNDERSTAND the damage mechanisms of materials under quasi-static, time dependent and varying direction (and magnitude) loading. 2) EVALUATE the life of materials under fatigue loading conditions by considering environment and other factors. 3) EVALUATE the fracture parameters for linear elastic materials 4) EVALUATE the fatigue crack growth rate of materials for constant and variable amplitude fatigue loading 5)EVALUATE the fracture parameters for linear elastic materials undergoing large-scale plasticity

Learning Resources	**Text Books:** 1. Fatigue of Materials, S. Suresh, Cambridge University Press 2. Fracture Mechanics – Fundamentals and Applications, T. L. Anderson, CRC Press **Reference books:** 1. Theory of Elasticity, S. P. Timoshenko and J. N. Goodier, McGraw Hill 2. Mechanical Metallurgy, G. E. Dieter, McGraw Hill 3. Mechanical Behaviour of Materials, M. A. Meyers & K. K. Chawla, Cambridge University Press 4. Elements of Fracture Mechanics, P. Kumar, McGraw Hill 5. Elementary Engineering Fracture Mechanics, D. Broek, Kluwer Academic Publishers

8th Semester

Course Code	ME4223N	Course Name	Industrial Tribology	Course Category	OE5	L	T	P
						3	0	0

Pre-requisite Courses	*Design of machine elements*	Co-requisite Courses	*Mathematics*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*			**Data Book / Codes/Standards**	*Nil*

Course Objective	The goal of the course is to provide students a fundamental understanding of the tribology at the contact between two surfaces. Characterizations of surfaces are discussed, and associated numerical models are addressed. Friction and different wear phenomena are discussed. Emphasis is given to tribo-testing instruments and lubricants.

Module	Syllabus	Duration (class-hour)	Module Outcome
01	Tribology - Introduction, A brief history of tribology, Industrial importance	02	Understanding of basics of tribology.
02	Engineering Surfaces - Properties and Measurement, Contact and Non-contact type surface roughness measuring instruments, Optical & Electron Microscope, Centre Line Average (CLA) and Root Mean Square (RMS) Roughness, Abbott-Firestone Bearing Area Curve, Probability Distribution Function, Skewness, Kurtosis, Auto-correlation Function (ACF), Asperity slope and curvature, Power Spectral Density Function, Fractal Description	06	Addressing configurations of engineering surfaces, and their statistical evaluations.
03	Non-conforming surface contact geometry, Surface and sub-surface stress distributions of point and line contact, Greenwood and Williamson's model for contact between two rough flat surfaces – expected number of asperity contacts, real area of contact and concept of plasticity index	05	Understanding of contact geometry, and Greenwood and Williamson's model.
04	Adhesion at Solid-Solid Contact, Factors influencing adhesion, E. Rabinowicz's Compatibility Chart of Solid Solubility Versus Work of Adhesion, Genesis of Solid Friction, Amontons laws of friction, Bowden and Tabor's Simple Adhesion Theory, Modified Adhesion Theory – Junction Growth, Deformation Theory – Ploughing	04	Addressing different contact configurations, and adhesion theories.
05	Wear Mechanisms and Modelling – Adhesive Wear, Abrasive Wear, Erosive Wear, Cavitational Wear, Chemical Wear, Surface Fatigue Wear	07	Addressing wear mechanisms.
06	Tribo-testers – Pin/Ball-on-Disc Machine, Talysurf (Surtronic 3+), Optical Profilometer, Electronic Weighing Balance, Ultrasonic Vibro-cleaning Bath, Micro-Hardness Indenter	03	Addressing different tribo-testers along with associated measuring instruments.
07	Wear Resistant Materials	02	Addressing different wear resistant materials for industry use.

08	Liquid Lubricants – Properties and Measurement, SAE Classifications, Effect of Temperature, Pressure and Shear Rates on Viscosity, Flash Point, Pour Point, Specific Heat and Thermal Conductivity, Oxidation Stability, Solid Lubricants, Additives	06	Understanding of lubricant configurations.
09	Lubrication Regimes Versus Film Thickness Ratio – Hydrodynamic Hydrostatic Lubrication, Elasto-Hydrodynamic Lubrication (EHL), micro-EHL, Boundary Lubrication Applications	04	Addressing hydrodynamic, hydrostatic, and boundary lubrication theories and their scopes of application.
10	Class Test	01	Evaluating proficiency levels of the students in this subject.
	Total	**40**	

Course Outcome	At the end of the course, students should be able to 1. Understand the basic aspects of tribology. 2. Understand surface characteristics like roughness, skewness, kurtosis, *etc*. 3. Understand contact mechanisms at surface level. 4. Conceptualize adhesion phenomenon at the contact, and measure friction and wear values during the sliding of two bodies through tribo-testing tools. 5. Conceptualize lubrication.

Learning Resources	**Text Book** 1. Engineering Tribology - J. A. Williams, Oxford University Press, Reprint 1996 **Reference Books** 1. Fundamentals of Fluid Film Lubrication - B. J. Hamrock (McGraw Hill International) 2. The principles of lubrication - A . Cameron, Longman Publication, 1966 3. Engineering Tribology – Prasanta Sahoo, Prentice-Hall of India Pvt. Ltd., 2005 4. Friction and Lubrication of Solids – Part I & Part II , F. P. Bowden and D. Tabor, Oxford University 5. Contact Mechanics – K. L. Johnson, Cambridge University Press 6. Tribophysics – Nam P. Suh, Prentice-Hall INC Press.

8th Semester

Course Code	ME4224N	Course Name	Project Management	Course Category	OE5	L	T	P
						3	0	0

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department		*Mechanical Engineering*		**Data Book / Codes/Standards**	*Nil*

Course Objective	To impart knowledge about resource allocation, market and demand analysis, technical analysis, economic and ecological analysis related to project management. To understand network techniques for project monitoring and control.

Module	Syllabus	Duration (class-hour)	Module Outcome
1.	**Introduction:** Introduction to Project Management, History of Project Management, Types & Characteristics of Projects, Project Life Cycle. Project Identification and Screening.	13	Impart knowledge about project management, project life cycle and project screening process
2.	**Project Analysis:** Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis. Cash flows for project appraisal- Investment evaluation using capital budgeting techniques, net present value, profitability index, internal rate of return, payback period, accounting rate of return.	18	Learn about various project facet analysis techniques
3.	**Network Technique for Project Management:** Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, CPM Model, Time and Cost trade-off in CPM, Crashing procedure of project	06	Learn about project network construction and monitoring techniques
4.	Work Breakdown structure, coordination and control, Project organization structure, Project Management Software.	04	Impart knowledge about project management tools and techniques
	TOTAL	**41**	

Course Outcome	Students will be able to: 1. Understand the concept of projects and its phases. 2. Analyse project from marketing, operational and financial perspective. 3. Develop network diagrams for planning and execution of a given project

Learning Resources	**Text book** 1. P. Chandra, Project: A Planning Analysis, McGraw Hill Book Company, New Delhi, 2017 **Reference book:** 1. 1. C.F. Grey, E.W. Larson and G.V. Desai, Project Management the Managerial Process, McGraw Hill Education (India), New Delhi, 1990. 2. K. Harold, Project Management: A Systems Approach to Planning, Scheduling and Controlling, Wiley Student Edition, 2013.

	3. J.D. Wiest and F.K. Levy, A Management Guide to PERT/ CPM with PERT/ PDM/ DCPM and Other Networks, PHI Learning Private Limited, 1970. 4. A. Kanda, Project Management: A Life Cycle Approach, PHI, 2010.