Course Curriculum for B. Tech. (New)

in

Mechanical Engineering

(For students admitted in 2019-20 onwards)

Mechanical Engineering Department

National Institute of Technology Arunachal Pradesh

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1.0 Semester wise Credit point distribution

Sl. No.	Year	Credit Point	
		ODD	EVEN
1	First	18.5	20.5
2	Second	20	23
3	Third	20	22
4	Fourth	19	17
Total Credit Point		**77.5**	**82.5**
		160	

1.1 Subject Category wise Credit point Distribution

Course Category	Sem-I	Sem-II	Sem-III	Sem-IV	Sem-V	Sem-VI	Sem-VII	Sem-VIII	Total Credit Point
Core (Basic Science)	**7**	**10**	**4**	**3**	--	--	--	--	**24**
Core (Engineering Science)	**6**	**3**	--	--	--	--	--	--	**9**
Core (Professional)	--	--	**11**	**15**	**18**	**19**	**3**	--	**66**
Core (Humanities)	**3**	**3**	**3**	**3**	--	--	--	--	**12**
Elective (Professional)	--	--	--	--	--	--	**6**	**3**	**9**
Open Elective	--	--	--	--	--	--	**3**	--	**3**
Elective (online course)	--	--	--	--	--	--	--	**3**	**3**
Lab (Basic Science)	**1**	**1**	--	**1**	--	--	--	--	**3**
Lab (Engineering Science)	**1.5**	**3.5**	--	--	--	--	--	--	**5**
Lab (Humanities)	--	--	--	--	--	--	--	--	--
Lab (Professional)	--	--	**2**	**1**	**2**	**2**	--	--	**7**
Internship	--	--	--	--	**1**	**1**	**1**	--	**3**
Academic Project	--	--	--	--	--	--	**6**	**8**	**14**
Audit (NSS/NCC)	**0**	**0**	--	--	--	--	--	--	**0**
Grand Viva	--	--	--	--	--	--	--	**2**	**2**
Total Credit Point	**18.5**	**20.5**	**20**	**23**	**21**	**22**	**19**	**16**	**160**

2.0 COURSE STRUCTURE

Ist Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	CY-101	Engineering Chemistry	3	0	0	3
2	CY-102	Engineering Chemistry Lab	0	0	2	1
3	MA-101	Engineering Mathematics I	3	1	0	4
4	ME-101	Engineering Mechanics	3	0	0	3
5	ME-102	Workshop Practice I	0	0	3	1.5
6	MH-101	Communication Skill	0	3	0	3
7	BIO-101	Bio-Science	3	0	0	3
8	MH-113	NSS/NCC	0	0	2	0
Contact Hours			12	4	7	
Total Credits						18.5
IInd Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	PHY-101	Engineering Physics	3	0	0	3
2	PHY-102	Engineering Physics Lab	0	0	2	1
3	MA-102	Engineering Mathematics II	3	1	0	4
4	CY-108	Environmental Engineering	3	0	0	3
5	CS-112	Introduction to Compute Programming	2	0	0	2
6	CS-113	Introduction to Compute Programming Laboratory	0	0	4	2
7	ME-121	Engineering Drawing	1	0	3	2.5
8	MH-106	Fundamentals of Economics	3	0	0	3
9	MH-113	NSS/NCC	0	0	2	0
Contact Hours			15	1	11	
Total Credits						20.5
IIIrd Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	ME-201	Solid Mechanics	3	1	0	4
2	ME-202	Material Science	3	0	0	3
3	ME-203	Basic Thermodynamics	3	1	0	4
4	MA-201	Probability and Statistics	3	1	0	4
5	MH-201	Introduction to Human Values& Ethics	3	0	0	3
6	ME-204	Machine Drawing	0	0	2	1
7	ME-205	Workshop Practice-II	0	0	2	1
Contact Hours			15	3	4	
Total Credits						20
IVth Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	ME-221	Fluid Mechanics-I	3	1	0	4
2	ME-222	Manufacturing Technology-I	3	0	0	3

3	ME-223	Machine Design-I	3	1	0	4
4	ME-224	Kinematics of Machinery	3	1	0	4
5	MA-203	Numerical Methods	3	0	0	3
6	MH-206	Entrepreneurship	3	0	0	3
7	MA-204	Numerical Computing Lab	0	0	2	1
8	ME- 225	Mechanical Laboratory- I	0	0	2	1
Contact Hours			18	3	4	
Total Credits						23
Vth Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	ME-301	Dynamics of Machinery	3	1	0	4
2	ME-302	Fluid Mechanics-II	3	1	0	4
3	ME-303	Applied Thermodynamics	3	1	0	4
4	ME-304	Measurement and Control	3	0	0	3
5	ME-305	Manufacturing Technology-II	3	0	0	3
6	ME-306	Mechanical Laboratory- II	0	0	2	1
7	ME-307	Mechanical Laboratory- III	0	0	2	1
8	ME-390	Internship-I	0	0	0	1
Contact Hours			15	3	4	
Total Credits						21
VIth Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	ME-321	Industrial Engineering & Operation Research	3	1	0	4
2	ME-322	Heat and Mass Transfer	3	1	0	4
3	ME-323	Machine Design-II	3	1	0	4
4	ME-324	IC Engines	3	1	0	4
5	ME-325	Computer Aided Design and Manufacturing	3	0	0	3
6	ME-326	Mechanical Laboratory- IV	0	0	2	1
7	ME-327	Mechanical Laboratory- V	0	0	2	1
8	ME-391	Internship-II	0	0	0	1
Contact Hours			15	4	4	
Total Credits						22
VIIth Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	ME-401	Mechatronics	3	0	0	3
2	ME-402x	Elective-I	3	0	0	3
3	ME-403x	Elective- II	3	0	0	3
4	OE-XXX	Open Elective*	3	0	0	3
5	ME-490	Internship-III	0	0	0	1
6	ME-491	Project Phase-I & Dissertation	0	0	12	6
Contact Hours			12	0	12	
Total Credits						19
VIIIth Semester						
Sl No	**Course Code**	**Course Title**	**L**	**T**	**P**	**C**
1	ME-421x	Elective- III	3	0	0	3

2	ME-422x	Elective- IV	3	0	0	3
3	ME-492	Project Phase-II & Dissertation	0	0	16	8
4	ME-493	Grand Viva	0	0	0	2
Contact Hours			6	0	16	
Total Credits						16

3.0 List of subjects offered under electives

Elective-I (ME-402x)	Elective-II (ME-403x)	Elective-III (ME-421x)	Elective-IV (ME-422x)
Refrigeration and Air-conditioning (ME-402A)	Advanced Solid Mechanics (ME-403A)	Details given in section 5.0	Details given in section 5.0
Conduction and Radiation (ME-402B)	Mechanical Vibration (ME-403B)		
Advanced Fluid Mechanics (ME-402C)	Advanced Machining Processes (ME-403C)		
Gas Turbine Technology (ME-402D)	Robotics (ME-403D)		
Turbomachinery (ME-402E)	Principles of Product Design (ME-403E)		
Automobile Engineering (ME-402F)	Experimental Methods (ME-403F)		
Fuels and Combustion (ME-402G)	Principle of Tribology (ME-403G)		
Renewable Energy (ME-402H)	Advanced Thermodynamics (ME-403H)		
Computational Fluid Dynamics (ME-402I)			

4.0 Open elective (offered by other department)—[OE-XXX]

- Students are free to choose any subjects of their interest offered as open electives by other department of the Institute.
- The course has to be of 3 credits.
- The list of subjects offered by Mechanical Engineering Department as open elective for the students of the other department is listed in section 3.0. However, at the beginning of the semester, HoD, Mechanical will notify the specific subject offered as an open elective.

5.0 Elective-III & IV

- These two courses will be chosen from NPTEL (https://nptel.ac.in/)/SWAYAM portal (https://swayam.gov.in).
- Student can enrol in 4th year (7th& 8th semester). However the courses will be credited in 8th semester only.
- Courses will be of completely student's choice and should be of at least of 12 weeks including tutorials which will be considered as 3 credit course.
- The choice of courses should be from outside the core and electives offered / opted.

6.0 Internship

- Internship-I: Student will go for internship during summer vacation (after 4th semester) for a period of 4 weeks. The assessment will be done on 5th semester
- Internship-II: Student will go for internship during winter vacation (after 5th semester) for a period of 4 weeks. The assessment will be done on 6th semester
- Internship-III: Student will go for internship during summer vacation (after 6th semester) for a period of 4 weeks. The assessment will be done on 7th semester
- At least one internship has to be done in Industry preferably during Internship-III.

7.0 Institute Vision

To transform into an acclaimed institution of higher learning with creation of an impact on the north eastern region in terms of innovation and entrepreneurship.

8.0 Institute Mission

1. To generate new knowledge through state of the art academic program and research in multidisciplinary field.
2. To identify regional, Indian and global need to serve the society better.
3. To create an ambience to flourish new ideas, research and academic excellence to produce new leaders and innovators.
4. To collaborate with other academic, research institutes and industries for holistic growth of the students.
5. Utilization of available big resources to encourage entrepreneurship through formation of startups.

9.0 Departmental Vision

To produce competent mechanical engineers for generation of state of the art technology, innovative products and challenging entrepreneurs for overall development of the society.

10.0 Departmental Mission

1. To impart quality education with holistic approach to cater the needs of Industry and society.
2. To develop state of the art laboratories and centre of excellence for teaching, research and innovation.
3. To encourage collaborative work in multidisciplinary field with Industries and other research Organizations.
4. To create an ambience for entrepreneurship development with special emphasis to resource utilization of North-East region.

11.0 Program Outcomes (POs)

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

12.0 Program Educational Objectives (PEOs)

PEO1	Graduates will be able to apply technical knowledge and skills as Mechanical Engineers to provide the solutions for the industries and society.
PEO2	Graduates will be able to work in multidisciplinary environment developing complex mechanical systems.
PEO3	Encourage establishing own start-ups to become competent entrepreneur.

13.0 Program Specific Outcomes (PSOs)

PSO1	Ability to identify, formulate and solve engineering problems in three core streams of Mechanical Engineering, i.e. design engineering, thermal and fluids engineering and manufacturing engineering.
PSO2	Ability to prepare and execute the plan to manufacture components / assembly / processes and systems.
PSO3	Engage professionally and ethically in industries or as an entrepreneur by incorporating technological and managerial skills and build the attitude of developing new concepts on emerging fields and pursuing advanced education.

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Semester-I

Name of the Module: Engineering Mechanics
Module Code: ME-101
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. Ability to utilise scalar and vector analytical techniques for analysing forces in statically determinate structures.
2. Ability to apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems.
3. Student gets a basic idea of Centre of gravity, moment of inertia, mass moment of inertia, friction.

B. Course Content:

Forces and Moments: Force, Moment and Couple, Wrench, Equivalent force and moment, Forces in space equilibrium, FBD, general equations of equilibrium-Lami's theorem, analysis of forces in truss and frames, brief introduction to vector approach.

Friction: Introduction to dry friction, laws of friction, friction of simple machines, inclined planes, Screw jacks, clutch, and collar pivot bearing (uniform wear and uniform pressure assumptions).

Centre of gravity and moment of inertia: Centre of gravity, volume and composite bodies, Area moment of inertia and mass moment of inertia for plane figures and bodies.

Dynamics: Kinematics and Kinetics, Rectilinear motion of particles, determination of position velocity and acceleration under uniform rectilinear motion (uniform and non-uniform accelerated rectilinear motion), Relative motion, construction of x-t, v-t and a-t graphs (simple problems),Projectile motion, Normal and Tangential components, Radial and Transverse components, simple problems, Equation of motion, D. Alembert's principle, principle of virtual work, planar kinematics and kinetics of system of particles and rigid bodies.

C. Text Books:

1. *Timoshenko S. and Young D.H., "Engineering Mechanics", 5th Ed., 2017, MGH.*
2. *Beer and Johnston, "Vector Mechanics for Engineers: Statics and Dynamics", 10th Ed., 2012, TMGH.*

D. Reference Books:

1. *Meriam, J. L. and Kraige, L. G., "Engineering Mechanics, Volume 1: Statics", 8th Ed., 2017, Wiley.*
2. *Meriam, J. L. and Kraige, L. G., "Engineering Mechanics, Volume 2: Dynamics", 5th Ed., 2006, Wiley.*
3. *Shames, I. H. and Rao,G. K., "Engineering Mechanics: Statics and Dynamics'", 4th Ed., 2006, Pearson.*

E. Course Outcomes: Upon completion of the subject, students should have the knowledge of:

1. Basic understanding of different type of forces, moments and resolving them.
2. Evaluation of centre of gravity, moment of inertia and mass moment of inertia for various figures & bodies.
3. Apply principles of kinematics, kinetics and effects of friction for solving problems.

Name of the Module: Workshop Practice-I
Module Code: ME-102
Credit Value: 1.5 [L = 0, T = 0, P = 3]

A. Course Objectives: The course is designed to meet the following objectives:

1. Acquire skills in basic engineering practice.
2. Identify the hand tools and instruments.
3. Acquire measuring skills.
4. Acquire practical skills in the trades.
5. Acquire practical skills in welding, carpentry and fitting.

B. List of Experiments:

1. Study of various hand tools.
2. Making various joints (carpentry, fitting, sheet metal)
3. Welding (surface preparation and welding practice)
4. CNC assembly/disassembly (lathe and milling using kit)
5. 3-D printing (assembly kit)

C. Reference Books:

1. *Choudhury, S. K. H., Choudhury, A. K. H., Roy, N., "Elements of Workshop Technology" Vol-1, 2008, Media promoters & pubmishers pvt ltd.*
2. *Begeman, M. L. and Amstead, B. H., "Manufacturing Process" 8th Ed., 1987, Wiley.*

3. *Chapman, W. A. J. and Arnold E., "Workshop Technology, Vol. I, II & III", 5th, 4th and 3rd Eds, 2001, 2005 and 1995, CRC press, Prentice Hall.*

D. Course Outcomes:
Upon completion of the subject, students should have the knowledge of:
1. Handling and working principles of various tools, machines and also safety aspects followed in workshop.
2. Hands on experience on different welding techniques.
3. Preparation of different sheet metal & fitting joints.
4. Assembly and disassembly of CNC machines & assembly of 3D printing.

Semester-II

Name of the Module: Engineering Drawing
Module Code: ME-121
Credit Value: 2.5 [L = 1, T = 0, P = 3]

A. Course Objectives: The course is design to meet with the following objectives:
1. Increase ability to understand Engineering Drawing.
2. Learn to sketch and take field dimensions.
3. Learn to take data and transform it into graphic drawings.
4. Learn basic Auto Cad skills.
5. Learn basic engineering drawing formats.
6. Prepare the student for future Engineering positions.

B. Course Content:
Indian Standards: Sheet layout, type of lines and their representations, scales.

Principles of Orthographic Projection (multi view drawing): 1stand 3rdangle projection.

Projections: Points, lines, surfaces and solids.

Projection of sections and intersections of solids; Isometric projection.

C. Reference Books:
1. *Dhananjay, A. J., "Engineering Drawing", 1st Ed., 2017, TMH.*
2. *Bhatt, N.D. and Panchal, V.M., "Engineering Drawing", 43rd Ed., 2014, Charotar Publishing House Pvt.Ltd.*
3. *Venugopal, K. and Prabhu,V. R., "Engineering Graphics", 15th Ed., 2018, New Age International Pvt. Ltd.*

D. Course Outcomes: Upon completion of the subject student's ability to**:**
1. Understand orthographic projections and sections.
2. Basic understanding of Indian standards of Engineering drawing.
3. Develop engineering drawings by projection techniques.
4. Utilise AutoCAD towards developments of drawings.

Semester-III

Name of the Module: Solid Mechanics
Module Code: ME-201
Credit Value: 4 [L = 3, T = 1, P =0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To establish an understanding of the fundamental concepts of mechanics of deformable solids; including static equilibrium, geometry of deformation, and material constitutive behavior.
2. To understand and apply for evaluation of stress and deformation in simple geometries such as bars, beams, shafts, for various types of load conditions.
3. To build the necessary theoretical background to be utilized in design courses.

B. Course Content:

Introduction and Concept of Stress: Load, Stress, Principle of St.Venant, Principle of Superposition, Strain, Hooke's law, Modulus of Elasticity, Stress-Strain Diagrams, Working Stress, Factor of safety, Strain energy in tension and compression, Resilience, Impact loads.

Analysis of Axially Loaded Members: Composite bars in tension and compression, temperature stresses in composite rods, Concept of Statically indeterminate problems. Shear stress, Complimentary shear stress, Shear strain, Modulus of rigidity, Poisson's ratio, Bulk Modulus, Relationship between elastic constants.
Biaxial State of Stress: Analysis of Biaxial Stress. Plane stress, Principal plane, Principal stress, Mohr's Circle for Biaxial Stress. Stresses in thin cylinders and thin spherical shells under internal pressure, wire winding of thin cylinders.

Biaxial State of Strain: Two dimensional state of strain, Principal Strains, Mohr's circle for strain, Calculation of principal stresses from principal strains, Strain Rossette.

Shear Force and Bending Moment Diagrams: Shear force and bending moment, Types of load and Types of support. Support reactions, Relationship between bending moment and shear force, Point of inflection. Shear Force and Bending Moment diagrams.

Analysis of Beams for Bending: Theory of simple bending of initially straight beams, pure bending, Bending stresses, Shear stresses in bending, Distribution of normal and shear stress, Composite beams.

Deflection of Beams: Differential equation of the elastic line, Slope and deflection of beams by integration method and area - moment method.

Torsion: Torsion in solid and hollow circular shafts, Twisting moment, Strain energy in shear and torsion, strength of solid and hollow circular shafts. Strength of shafts in combined bending and twisting.

C. Text Books:

1. *Shames, I. H., "Introduction to Solid Mechanics", 3rd Ed., 2015, Prentice Hall.*
2. *Ryder, G. H., "Strength of Materials", 3rd Ed., 1969, Macmillan Press.*

D. Reference Books:

1. *Beer and Johnston, "Mechanics of Materials", 7th Ed., 2017, McGraw Hill.*

E. Course Outcome: Upon completion of the subject, the students should:

1. Have the basic concepts on various loadings and their effects on different elements.
2. Be able to analyze simple geometries subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behaviour of materials.
3. Be able to evaluate strain and deformation that will result due to internal stress developed under simple load conditions.
4. Be able to apply the knowledge in designing machine parts and structures to prevent failure.

Name of the Module: Material Science
Module Code: ME-202
Credit Value: 3 [L = 3, T = 0, P =0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between microstructure, properties and processing.
3. Have the experimental skills for a professional career or graduate study in materials.
4. Design and selections of materials for specific application.
5. Be able to communicate effectively, to work in teams and to assume positions as leaders.

B. Course Content:

Introduction: Material Science, definition and its importance in relation to mechanical engineering, Application of various materials in mechanical engineering.

Crystallography: Crystal lattice, seven crystal system and fourteen bravis lattices, relationship between atomic diameter and lattice parameter in SC, BCC, FCC, HCP crystals. Coordination numbers, atomic packing factor and voids in above mentioned crystals. Introduction to Defects in crystal: point defect, line defect.

Alloys and Phase diagram: Types of alloys, solid solutions, substitutional and interstitial solid solutions, factors affecting solid solubility (Hume Rothary rules), Gibbs phase rule, Lever rule.

Binary Phase Diagram: Isomorphous, eutectic, peritectic, eutectoid and peritectoid system. Equilibrium in above binary phase diagrams. Iron carbon equilibrium phase diagram and micro structure in plain carbon steel, non-equilibrium solidification in plain carbon steel. Transformation curves – Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT) curves.

Heat Treatment: Various heat treatment processes– Annealing; Recovery, Recrystallization and Grain growth, Normalizing, Hardening, Tempering, Martempering, Austempering, Concept of hardenability, Factors affecting it hardenability, Surface hardening of steel; carburizing, cyaniding, nitriding, flame hardening and induction hardening etc.

Ferrous Alloys: classification and properties of ferrous allots; plain carbon steel, medium carbon steel, high carbon steel, different alloy steel and cast iron properties.

Non-Ferrous Alloys: Properties, Compositions and uses of most commonly used non-ferrous alloys such as Al, Mg, Cu, Ti, Zn alloys etc. alloys**.**

General Introduction to Advanced Materials: Smart materials, shape memory alloys, magneto rheological fluid, electro rheological fluids, biomaterials.

C. Text Books:

1. *Smith, W., "Foundations of Materials Science and Engineering", 5th Ed., 2009, McGraw Hill.*
2. *Callister, W. D., "Material science and Engineering and Introduction", 5th Ed., 2016, Wiley.*

D. Reference Books:

1. *Raghavan, V., "Materials Science and Engineering", 6th Ed., 2015, PHI.*

E. Course Outcomes: Upon completion of the subject, the students should be able to:

1. Have a thorough knowledge regarding various metals and their crystal structure.
2. Select materials; design the heat treatment for specific needs.
3. Correlate the heat treatment to the microstructure and mechanical properties of industrial alloys.
4. Decide the processing condition of alloys based on phase diagram.

Name of the Module: Basic Thermodynamics
Module Code: ME-203
Credit Value: 4 [L = 3, T = 1, P =0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. Understand basic definitions and terminology.
2. Identify special definitions from the thermodynamics point of view.
3. Discover why and how natural processes occur only in unidirectional way.
4. Understand the concept of property and how it defines the state thermodynamic.
5. Identify the change of state results in a process.
6. Determine why processes are required to build cycles.
7. Recognize the differences between work producing and work consuming cycles.

B. Course Content:

Fundamental Concepts: Macroscopic and Microscopic viewpoints, System, Thermodynamic State. Properties, Process and Cycles, Work and Heat, Thermodynamic Equilibrium, Zeroth law of thermodynamics, temperature.

First Law of Thermodynamics: First Law applied to closed and open systems, Internal Energy, Enthalpy, Specific Heats, Perpetual motion machine of first kind (PMMI), Steady flow energy equation (SFEE), Application of SFEE to various Engineering systems.

Second Law of Thermodynamics: Statements of the Second Law of Thermodynamics and their equivalence, Reversibility and Irreversibility, Carnot cycle, Carnot Theorem, Absolute Thermodynamic Temperature Scale. Clausius Theorem and Inequality, Entropy Principle, Entropy changes during various processes, Concept of Third Law of Thermodynamics, Availability.

Properties of Pure Substances: P-V, P-T, T-s and h-s diagrams of a pure substance, Sensible Heat, Latent Heat, Saturation Temperature, Dryness fraction, steam table, Mollier diagram,

Properties of Ideal gases and Their mixtures: Gases-Equation of state of an Ideal Gas, Thermodynamic property relations, Specific Heats, Internal Energy, Enthalpy and Entropy change of Ideal Gases. Equation of state of Real Gases, Principle of corresponding state, Compressibility Factor.

Thermodynamic Cycles: Carnot cycle, Rankine cycle, Re-heat cycle, regenerative cycle, Otto, Diesel, Dual, Atkinson, Stirling cycles etc.

C. Text Books:

1. Nag, P. K., "Engineering Thermodynamics", 6th Ed., 2017, McGraw Hill.

2. Sonntag, R. E., Borgnakke, C., Wylen, G. J. V., "Fundamentals of Thermodynamics", 6th Ed., 2012, John Wiley.

D. Reference Books:

1. Cengel, Y. A., Boles, M. A., "Thermodynamics, An Engineering Approach", 8th Ed., 2017, McGraw Hill Education.

E.Course Outcomes: Upon completion of the subject, the students should be able to:

1. Understand of the first and second laws of thermodynamics and their application to a wide range of systems working with pure substance and gaseous mixtures.
2. Analyse the work and heat interactions associated with a prescribed process, path, and to perform a first law analysis of a flow and non-flow process.
3. Evaluate entropy changes in a wide range of processes and determine the reversibility and irreversibility of a process from such calculations.
4. Apply pressure-temperature diagrams, volume-temperature and pressure-volume phase diagrams and the steam tables for the analysis of engineering devices and systems.

Name of the Module: Machine Drawing
Module Code: ME-204
Credit Value: 1 [L = 0, T = 0, P =2]

A. Course Objectives: The course is design to meet with the following objectives:

1. Increase ability to understand Engineering Drawing.
2. Learn to sketch and take field dimensions.
3. Learn to take data and transform it into graphic drawings.
4. Learn basic Auto Cad skills.
5. Learn basic engineering drawing formats.
6. Prepare the student for future Engineering positions.

B. Course Content:

Review of orthographic projections and sectioning.

IS/ISO codes; Limits, tolerances and Fits, Surface finish; Symbols for weldments, process flow, electrical and instrumentation units.

Assembly and Part Drawings of simple assemblies and subassemblies of machine parts such as Couplings, Clutches, Bearings, Gear assemblies.
I.C. Engine components, Valves, Machine tools, etc. Introduction to solid modellers. A drawing project on reverse engineering.

C. Text Books:

1. *Bhatt, N. D., "Machine Drawing", 53rd Ed., 2014, Charotar Book Stall, Anand.*
2. *Sidheswar, N., Kanniah, P., Sastry, V. V. S., "Machine Drawing", 1st Ed., 2001, Tata McGraw Hill.*
3. *SP 46: 1988 Engineering Drawing Practice for School & Colleges. Bureau of Indian Standards.*

D. Course Outcomes: Upon completion of the subject student's ability to:

1. Learn basic understanding on development of manufacturing drawings.
2. Understand tolerance and symbols used for different operations and fit.
3. Development of part and assembly drawings of different mechanical systems.
4. Utilisation of engineering tools for development of solid models.

Name of the Module: Workshop Practice-II
Module Code: ME-205
Credit Value: 1 [L = 0, T = 0, P =2]

A. Course Objectives: The course is designed to meet the following objectives:

1. Acquire skills in basic engineering practice.
2. Identify the hand tools and instruments.
3. Acquire measuring skills.
4. Acquire practical skills in the trades.
5. Acquire practical skills in welding, carpentry, fitting.

B. List of experiments

1. Introduction to machine tools and machining processes.
2. Types of cutting tools, selection of machining parameter like cutting speed, feed and depth of cut.
3. Simple machining operations on lathe, shaper, drilling, milling and grinding machines.
4. Modern trends in manufacturing, automation, NC/CNC, FMS, CAM and CIM.

C. Reference Books:

1. *Choudhary, K., Roy, N., "Elements of Workshop Technology", Volume I and II, 1964, Media Promoters and Publishers Pvt. Ltd.*
2. *Chapman, W. A. J. and Arnold E., "Workshop Technology, Vol. I, II & III", 5th, 4th and 3rd Ed., 2001, 2005 and 1995, CRC press, PrenticeHall.*
3. *Gerling, H., "All about Machine Tools", 2nd Ed., 2006, New Age International, 1995.*

D. Course Outcomes: Upon completion of the subject, students should have the knowledge of:

1. Selection of proper tools based on the manufacturing process.
2. Understanding of machining parameters and their practical use.
3. Experimentation on different machines.
4. Trends in manufacturing automation.

Semester-IV

Name of the Module: Fluid Mechanics - I
Module Code: ME-221
Credit Value: 4 [L = 3, T = 1, P =0]

A. Course Objectives: The course is designed to:

1. Illustrate the properties of fluids and the applications of fluid mechanics.
2. Understand the fundamental of kinematics and dynamics of fluid flows and the governing non-dimensional parameters of a fluid element.
3. Apply the concepts of mass, momentum and energy conservation to flows.
4. Describe the fundamentals of incompressible viscous flow, various flow measurement devices and boundary layer concepts.
5. Solve simplified problems analytically.

B. Course Content:

Introduction: Introductory concepts, properties and classification of fluids, basic hydrostatic equation, measurement of pressure, forces on submerged plane and curved surfaces, buoyancy and stability.

Kinematics of Fluids: Streamline, path line, streak line, scalar and vector fields, flow field and description of fluid motions, deformation of fluid element.

Conservation Equations: integral and differential formulations - conservation of mass, conservation of momentum and conservation of energy; Bernoulli equation, stream function, velocity potential and vorticity, Euler equation.

Principles of Physical Similarity and Dimensional Analysis: Introduction, concept and type of physical similarity, applications of dynamic similarity, dimensional analysis.

Some Incompressible Viscous Flows: Reynolds experiment, Plane Poiseuille Flow, Hagen Poiseuille Flow, Couette Flow, losses in pipes, friction factors, Hydraulic diameter, Pipes in series and parallel.

Flow Measurement Devices: Pilot tube, venturi meter, orifice meter, orifice and mouthpieces, pitot static tube.

Boundary Layer Concept: Introduction to laminar boundary layer for flow over a flat plate – boundary layer thickness, displacement and momentum thickness.

C. Text Books:

1. *Som, S. K.,. Biswas, G and Chakraborty, S., "Introduction to Fluid Mechanics and Fluid Machines", 3rd Ed., 2017, TMH.*
2. *Munson, B. R., Young, D. F., Okiish, T. H., "Fundamental of Fluid Mechanics", 7th Ed., 2012, Wiley.*
3. *White, F. M., "Fluid Mechanics", 8th Ed., 2014, TMH.*

D. Reference Books:

1. *White, F. M., "Fluid Mechanics", 8th Ed., 2014, TMH.*
2. *Fox, R. W., McDonald, A. T., Pritchard, P. J., "Introduction to Fluid Mechanics", 6th Ed., 2003, Wiley.*

E. Course Outcomes: Upon completion of the subject, the students should be able to:
1. Understand the basics of fluid statics, kinematics and dynamics.
2. Describe the fundamentals of incompressible viscous flow, various flow measurement devices and boundary layer concepts.
3. Analyse fluid flow problems with the applications of mass and momentum.
4. Apply principles of dimensional analysis and similitude to simple problems and use dimensionless parameters.

Name of the Module: Manufacturing Technology-I
Module Code: ME-222
Credit Value: 3 [L = 3, T = 0, P =0]

A. Course Objectives: The course is design to meet with the following objectives:
1. Identify the various manufacturing processes.
2. To understand the fundamentals of casting, welding, metal forming and powder metallurgy.
3. Examine the various manufacturing methods encountered in engineering practice.
4. Analyse the effect of process variables to manufacture defect free products.

B. Course Content:
Casting: Introduction, patterns, pattern materials, allowances, types of pattern, sand casting, green and dry sand casting process, types of sand, moulding sand and its properties, moulding sand composition, use of cores, core material, core prints, special moulding processes, die casting process, investment casting process, continuous casting process, vacuum-sealed casting process, casting defects, causes and remedies of defects.

Welding: Classification and application of welding, brazing and soldering process, principles and applications of various welding processes: gas welding, types of flames, shielded material, inert gas welding, tungsten arc welding, submerged arc welding, resistance welding, thermite welding, friction stir welding, high frequency welding etc. various welding defects.

Metal Forming: Elastic and plastic deformation, concept of strain hardening, hot and cold working processes, various metal forming techniques; rolling, forging, extrusion, wire and tube drawing. Machines and equipment for metal forming processes. Sheet metal forming: shearing, blanking, piercing, bending, stretch forming, metal spinning, and shear spinning, deep drawing.

Powder Metallurgy: Introduction to powder metallurgy, production of metal powders, compaction and sintering processes, secondary and finishing operations, economics, advantages and applications of powder metallurgy.

C. Text Books:
1. *Rao, P. N., "Manufacturing Technology: Foundry, Forming and Welding, Volume I", 5th Ed., 2018, Tata McGraw Hill.*
2. *Ghosh, A., Mallik, A. K., "Manufacturing Science", 2nd Ed., 2010, Wiley Eastern.*

D. Reference Books:
1. Kalpakjian, S., Schmid, S. R., "Manufacturing Processes for Engineering Materials", 5th Ed., 2009, Pearson education.

2. Dieter, G. E.,"Mechanical metallurgy", 3rd Ed., 2017, TMH.

E. Course Outcomes: Upon completion of the subject, students will be able to:
1. Describe the various manufacturing processes.
2. Interpret casting, welding, metal forming and powder metallurgy techniques.
3. Classify the various manufacturing methods encountered in engineering practice.
4. Evaluate the effect of process variables to manufacture defect free products.

Name of the Module: Machine Design-I
Module Code: ME-223
Credit Value: 4 [L = 3, T = 1, P =0]

A. Course Objectives: The course is design to meet with the following objectives:
1. To teach the students the basic steps forming the design process and demonstrating the fact that design problems are open-ended, require creativity and involve iterative solutions.
2. To teach the students design methodologies and simple stresses & applicability of factor of safety.
3. Will be able to design machine elements based on strength and stiffness.

B. Course Content:
Basics of Machine design: Introduction to Mechanical design, Overview of design and manufacturing procedure, Engineering Materials, Load-Stress-Strain analysis in machine parts, Deflection and stiffness in machine elements.

Design for Strength: Design for static loading, stress concentration, failures theories from static loading, Introduction to fatigue load, fatigue failure analysis and design, failure theories for fluctuating stress.

Design of Permanent Joints: Riveted joints, Welded joints.

Design of Non-Permanent Joints: Screws, Fasteners and Bolted joints, Keys, Knuckle and Cotter joints.

Design of shaft and shaft components: Design of shaft for static loading and fluctuating loads: pure torsion, simple bending, combined bending and torsion, combined bending, torsion and axial loads. Design of shaft couplings: Muff couplings, Rigid flange couplings, Flexible couplings: Bush-pin type.

Design of Mechanical Springs: Stresses and deflection of helical springs, closed and open coiled tension and compression springs and their ends, design of helical springs for static and fatigue loading. Design of leaf springs,

Design of Clutches and Brakes and Design of Belts.

C. Text Books:
1. *Norton, L. R., "Machine Design an Integrated Approach", 5th Ed., 2018, Pearson Education Asia.*
2. *Shigley, J. E., Mischke, C. R., "Mechanical Engineering Design", 9th Ed., 2018, Mcgraw Hill.*
3. *Bhandari, V. B., "Design of Machine Elements", 4th Ed., 2017, McGraw-Hill.*

D. Course Outcomes: Upon completion of the subjects, students will be able to:

1. Will have knowledge on design philosophy, design considerations for machine component design, design principals, material properties, engineering materials, standard and codes.
2. Will have basic understanding machine elements subjected to simple stresses for different loading conditions and theories of failure.
3. Will be able to apply knowledge in design of temporary joint e.g. cotter joint, knuckle joint, keys, bolted& coupling and permanent joints e.g. riveted and welded joints subjected to static load.
4. Will be able to design of machine components like shafts based on strength and stiffness, various springs and power screws.
5. Use of computerized tools for 3D design of machine elements.

Name of the Module: Kinematics of Machinery
Module Code: ME-224
Credit Value: 4 [L = 3, T = 1, P =0]

A. Course Objectives:

The course is design to meet with the following objectives:
1. To learn different Mechanism of Machine.
2. To learn different working principle of various types of Gears, Brakes, Cams.
3. To Learn how to Draw Velocity and Acceleration diagram for kinematics pairs.

B. Course Content:

Machine and mechanism - Definition, Mechanism and Machine, Link, Kinematic Pair, Degrees of freedom, Kinematic chain, Various types of joints, Degrees of freedom for plain Mechanism, Inversion, Different types of kinematic chain and their inversions. Kutzbach Criteria and Grubler Criteria.

Velocity and acceleration in mechanism - Analysis of Reciprocating Engine mechanism and Four bar mechanism, Relative velocity method, Velocity and acceleration in Four bar, Slider crank Mechanism, Instantaneous center Method, Kennedy‘s Theorem, Mechanical Advantage, Coriolli‘s Acceleration Component, Synthesis of Mechanism, Pantograph, Scott-Russel indicator diagram.

Mechanism Synthesis - Graphical methods of synthesis, relative pole and inversion methods, Chebychev spacing for precision positions, Freudenstein’s equation applicable to four bar linkages.

Brakes & Dynamometers - Classification of brakes, Analysis of simple block, Band and internal expanding shoe brake, braking of a vehicle. Absorption and transmission dynamometers, Prony brake, Rope brake dynamometer, belt transmission, torsion dynamometer.

Cams - Introduction, Types of followers, Cam profile Nomenclature, various types of motion of the follower-Uniform motion, Simple Harmonic, Uniform Acceleration and Retardation, Cycloidal, Cam profile construction for various types of followers.

Gear and Gear Trains - Gear Terminology and definitions, Analysis of mechanism Trains: Simple Train, Compound train, Reverted train, Epicyclic train and their applications.

C. Text Books:

1. *Shigley, J. E., Vicker, J. J., “Theory of Machines and Mechanisms”, 4th Ed., 2014, MGH.*

2. *Rao, J. S., "Mechanism and Machine Theory", 2nd Ed., 2010, Newage publishers.*
3. *Rattan, S. S., "Theory of Machine", 4th Ed., 2017, TMGH.*

D. Course Outcomes: Upon completion of the subject, students should know:

1. Have Basic knowledge on kinematics of various mechanisms to obtain specific motion in Machine.
2. Have Basic understanding of working principle of different types of Gears, Brakes, Cams.
3. Solve and evaluate kinematic parameters with the help of Velocity and Acceleration diagram for kinematics pairs.
4. Use of computerized tools for kinematic analysis of mechanisms.

Name of the Module: Mechanical Laboratory-I
Module Code: ME-225
Credit Value: 1 [L = 0, T = 0, P =2]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To understand the procedure of doing different tests like hardness, compression, torsion, tension and impact in various materials.
2. To impart knowledge about the testing of columns and beams and behaviour of materials.
3. To provide practical knowledge in verification of principles of fluid flow and Bernoulli's theorem.
4. To impart knowledge in measuring pressure, discharge and velocity of fluid flow.
5. To provide practice in estimating friction losses.
6. To impart training to use various flow measuring devices for making engineering judgments.

B. List of Experiments:

Solid Mechanics

1. Determination of hardness of a material using Brinell hardness testing machine, Rockwell hardness testing machine, Vickers hardness testing machine.
2. Determination of toughness of a material using Impact testing machine.
3. Determination of twisting moment of a material using Digital torsion testing machine.
4. To obtain the stress-strain curve by performing the tensile test for both ductile and brittle material in Universal Testing Machine (UTM).
5. Beam bending and deflection of beam with various boundary conditions.
6. Column buckling.

Fluid Mechanics-I

7. Bernoulli's Principle Demonstrator.
8. Metacentric Height Apparatus.
9. Orifice meter and venture meter for liquid (water) flow through pipe.
10. Determination of velocity of flow using Pitot tube.
11. Determination of discharge coefficient of notches.
12. Determination of friction factor as a function of Reynolds number in pipe flow.

C. Reference Books:

1. *Shames, I. H., "Introduction to Solid Mechanics", 3rd Ed., 2015, Prentice Hall.*

2. *Som, S. K.,. Biswas, G and Chakraborty, S., "Introduction to Fluid Mechanics and Fluid Machines", 3rd Ed., 2017, TMH.*

D. Course Outcomes: On successful completion of the course, the student will be able to:

1. Describe the behavior of materials upon normal external loads and identify various fluid flow measuring apparatus.
2. Predict the behavior of the material under impact conditions and demonstrate working principles of various fluid flow measuring instruments.
3. Experimentation on evaluation of material properties through solid mechanics principles.
4. Calculate the friction and measure the frictional losses in fluid flow.

Semester-V

Name of the Module: Dynamics of Machinery
Module Code: ME-301
Credit Value: 4 [L = 3, T = 1, P =0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To equip the student with fundamental knowledge of dynamics of machines so that student can appreciate problems of dynamic force balance, transmissibility of forces, isolation of systems, vibrations.
2. Develop understanding of dynamic balancing, flywheel analysis, gyroscopic forces and Moments.
3. Develop knowledge of analytical and graphical methods for calculating balancing of rotary and reciprocating masses.
4. Develop understanding of vibrations and its significance on engineering design.

B. Course Content:

Introduction - Dynamics of Rigid Bodies in Plane Motion, Static force analysis, Dynamic Force Analysis of Machines-Flywheel- Turning Moment Diagram for Engines and Speed Fluctuation; Power Smoothening by Flywheels, Governor- Speed Control By Governors; Dynamics of Governor Mechanisms, spherical Motion of Symmetrical Bodies and Gyroscopic Effects in Machines.

Balancing - Dynamics of Rotating Bodies; Unbalance Effects and Balancing of Inertia Forces; Field Balancing and Balancing Machines, Dynamics of Reciprocating Machines with Single Slider; Unbalance in Single Cylinder Engine Mechanisms, Unbalance in Multi-cylinder Engines -In-line, V-twin and Radial Engines; Balancing Techniques.

Vibration - Vibration of Mechanical Systems; Types of Vibration; Lumped Parameter Models; Linearization of System Elements; Degrees of Freedom; Types of Restoration and Dissipation Mechanisms; Types of Excitation, Free Un-damped Vibration of Single Degree of Freedom Systems; Determination of Natural Frequency; Equivalent Inertia and Stiffness; Energy Method; Phase Plane Representation, Forced Vibration with Harmonic Excitation; Un-damped Systems and resonance; Viscously Damped Systems; Frequency Response Characteristics and Phase Lag; Systems with Base Excitation; Transmissibility and Vibration Isolation; Whirling of Shafts and Critical Speed, Vibration of Two and Multi degree of Freedom Systems; Concept of Normal Mode; Free Vibration Problems and Determination of Natural Frequencies; Forced, Vibration Analysis; Vibration Absorbers; Approximate Methods -Dunkerley's Method and Holzer

Method, Free Vibration of Elastic Bodies; Longitudinal Vibration of Bars; Transverse Vibration of Beams; Torsional Vibration of Shaft; Approximate Methods - Rayleigh's Method and Rayleigh-Ritz Method.

C. Text books:

1. *Uicker, J. J., Pennock, G. R. and Shigley, J. E., 'Theory of Machines and Mechanisms', 3rd Ed., 2014, Oxford International Student edition.*
2. *Rattan, S. S., 'Theory of Machines', 4th Ed., 2014, TMH.*
3. *Thomson, W. T. and Dahleh, M. D., 'Theory of vibration with applications', 5th Ed., 2015, Pearson.*

D. Reference Books:

1. *Balachandran, B., Magrab, E. B., 'Vibrations' 2nd Ed., 2009, Cengage Learning.*
2. *Kelly, S. G., 'Fundamentals of Mechanical Vibrations', 2nd Ed., 2000, TMH.*

E. Course Outcomes: Upon completion of the subject, the students should be able to:

1. Basic understanding of dynamics in plane motion with force equilibriums.
2. Analyse slider crank and other mechanisms based on learnt techniques.
3. Understand basic principles of different rotating dynamic bodies.
4. Understand how to determine the natural frequencies of continuous systems and analyse stability of various systems.

Name of the Module: Fluid Mechanics - II
Module Code: ME-302
Credit Value: 4 [L = 3, T = 1, P = 0]

A. Course Objectives: The course is designed to:

1. Understand the concepts of boundary layers, its related equations and also the mechanics of viscous flow about immersed boundaries.
2. Apply the basic law of thermodynamics to a steady flow in a conduit to derive the general one dimensional flow equation.
3. Recognise the isentropic flow and normal shock to some flow systems such as discharge of air from tanks and nozzle configurations.
4. Formulate a general treatment of the common forms of turbomachines, covering basic fluid dynamics and thermodynamics of flow through passages and over surface with fundamental governing equations.
5. Describe the basic characteristics of radial and axial pumps, turbines and fans with different kinds of working medium.

B. Course Content:

Boundary Layer flows: Introduction, boundary layer equations, Blasius Solution, momentum-integral equation of boundary layer, separation of boundary layer, turbulent flat plate boundary layers.

Forces on submerged bodies: Drag and lift on a stationary body by flowing fluid, streamlined and bluff body, terminal velocity of a body, lift on an aerofoil.

Compressible Flow: Introduction, thermodynamic relations of perfect gases, speed of sound, pressure field due to a moving source, basic equations, flow through nozzles, stagnation and sonic properties, normal shock waves; oblique shock.

Turbomachines: Euler-equation for turbo-machines; Impact of Free Jets: Impulse momentum principle, Force exerted by the jet on stationary flat and curved plate, Hinged plate, Moving plate and Moving curve/vanes, Impulse turbine- Pelton wheel; Reaction turbine- Francis turbine, propeller turbine; Centrifugal pump; Performance parameters and characteristics of pumps and turbines; cavitation; net positive suction head (NPSH); positive displacement pumps; centrifugal and axial flow fans and compressors; slip, surging and chocking.

C. Text Books:

1. *Som, S. K.,. Biswas, G and Chakraborty, S., "Introduction to Fluid Mechanics and Fluid Machines", 3rd Ed., 2017, TMH.*
2. *Munson, B. R., Young, D. F., Okiish, T. H., "Fundamental of Fluid Mechanics", 7th Ed., 2012, Wiley.*
3. *Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachines, 5th Ed., 2005, Butterworth-Heinemann.*
4. *Oosthuizen, P.H. and Carscallen,W.E., Compressible Fluid Flow, 1st Ed., 2003, McGraw-Hill,.*

D. Reference Books:

1. *White, F. M., "Fluid Mechanics", 8th Ed., 2014, TMH.*
2. *Fox, R. W., McDonald, A. T., Pritchard, P. J., "Introduction to Fluid Mechanics", 6th Ed., 2003, Wiley.*

E. Course Outcomes: Upon completion of the subject, students should:

1. Understand the concepts of viscous boundary layers, boundary layer equations, Blasius solution, momentum integral equation to determine integral thicknesses, wall shear stresses, and skin friction coefficients.
2. Describe the principles and applications of turbomachinery in modern industry and apply the principles of fluid mechanics to the operation, design, and selection of fluid machinery such as pumps, fans, and turbines.
3. Evaluate the mechanics of viscous flow about immersed boundaries, as it relates to flow separation, wakes, profile drag, drag coefficients and the determination of drag forces exerted on such bodies.
4. Apply the compressible flow analysis to a pipe flow and compute the pressure losses due to friction, area change in the system and assess the performance of the system.

Name of the Module: Applied Thermodynamics
Module Code: ME-303
Credit Value: 4 [L = 3, T = 1, P = 0]

A. Course Objectives:

The course is designed to meet the following objectives:

1. To learn about gas and vapour cycles and their first law and second law efficiencies.
2. To understand about the properties of dry and wet air and the principles of psychometry.
3. To learn the about reciprocating compressors with and without intercooling.
4. To analyse the performance of steam turbines.

B. Course Contents:

Properties of pure substances, steam table, Mollier diagram, equation of state for real gases.

Vapour power cycles- Rankine cycle with superheat, reheat and regeneration, effect of reheat, regeneration and intercooling exergy analysis.

Gas power cycles- Air standard Otto, Diesel and Dual cycles -Air standard Brayton cycle - Combined gas and vapour power cycles, Vapour compression refrigeration cycles, refrigerants and their properties.

Refrigeration- vapour compression refrigeration cycles, vapour absorption refrigeration cycles, refrigerants and their properties, air refrigeration.

Properties of dry and wet air, use of psychometric chart, processes involving heating/cooling and humidification/dehumidification, dew point.

Basics of compressible flow. Stagnation properties, Isentropic flow of a perfect gas through a nozzle, choked flow, subsonic and supersonic flows, normal shocks, flow in diffusers, efficiency of nozzle and diffuser.

Reciprocating compressors, staging of reciprocating compressors, optimal stage pressure ratio, effect of intercooling, minimum work for multistage reciprocating compressors. Analysis of steam turbines, velocity and pressure compounding of steam turbines

C. Text Books:

1. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., Fundamentals of Thermodynamics, 6th Ed., 2006, John Wiley and Sons.
2. Jones, J. B. and Duggan, R. E., Engineering Thermodynamics, 1996, Prentice-Hall of India
3. Moran, M. J. and Shapiro, H. N., Fundamentals of Engineering Thermodynamics, 7th Ed., 2010, John Wiley and Sons.

D. Reference Books:

1. Nag, P.K, Engineering Thermodynamics, 6th Ed., 2017, Tata McGraw-Hill Publishing Co. Ltd.
2. Dossat, R. J. and Horan, T. J., Principles of Refrigeration, 5th Ed., 2001, Pearson.

E. Course Outcomes: After completing this course, the students will be able to:

1. Understand about various practical power cycles and heat pump cycles.
2. Evaluate the phenomena occurring in high speed compressible flows.
3. Analyse energy conversion in various thermal devices such as combustors, air coolers, nozzles, diffusers, steam turbines and reciprocating compressors.
4. Apply the knowledge of Mollier chart and psychometric to solve refrigeration and air conditioning problems.

Name of the Module: Measurement and Control
Module Code: ME-304
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To explain basic concepts and definitions of measurement and control.
2. To explain the measurement of different physical quantities.

3. To explain the control systems and related mathematical formulation.

B. Course Content:

Introduction to measurement: Generalized measurement system, standards, and types of signals, Static performance characteristics, Dynamic performance, general model, zero order, first order: step response and frequency response, second order: step response and frequency response.

Analysis of uncertainties: Error classification, systematic and random errors, statistical analysis of data, propagation and expression of uncertainties.

Measurement of physical quantities: Linear and angular displacement, velocity, force, torque, strain, viscosity, pressure, flow rate and temperature.

Introduction to control systems: Classification of control system. Open loop and closed loop systems.

Mathematical modelling of control systems: concept of transfer function, Block diagram algebra, Transient and steady state analysis of first and second order system. Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp and parabolic inputs.

C. Text Books:

1. *Doebelin, E. O., Manik, D. N., "Measurement Systems", 7th Ed., 2019, McGraw-Hill International.*
2. *Holman, J. P., "Experimental Methods for Engineers", 7th Ed., 2017, McGraw-Hill Company.*
3. *Kumar, D. S., "Mechanical Measurements and Control", 5th Ed., 2015, Metropolitan Book Co. (P) Ltd.*

D. Reference Books:

1. *Nelson A., "Engineering Mechanics: Statics and Dynamics", 1st Ed., 2017, TMGH.*
2. *Backwith, T. G., Marangoni, R. D. and Lienhard, J. H., "Mechanical Measurements", 5th Ed., 1993, Addison Wesley.*

E. Course Outcomes: Upon completion of the subject, students should be able to:

1. Understand basics of measurement regarding different physical quantity and control system.
2. Explain the accuracy of measuring instruments.
3. Analyse calibration of measuring instruments.
4. Evaluate control system for mechanical components.

Name of the Module: Manufacturing Technology-II
Module Code: ME-305
Credit Value: 3 [L=3, T=0, P=0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To understand the concept and basic mechanics of metal cutting.
2. To understand the working of standard machine tools such as lathe, shaping, milling, drilling and allied machines.
3. To understand the principles and techniques of finishing processes.

4. To understand the basic concepts of non-traditional machining processes.

B. Course Content:

Introduction: Classification of metal removal processes and machine tools, concepts of machining, basic working principle, configuration, specification and classification of machine tools.

Mechanics of machining: Geometry of single point cutting tools, conversion of tool angles from one system to another, mechanism of chip formation, orthogonal and oblique cutting, use of chip breakers in machining, machining forces and Merchant's Circle Diagram (MCD), analytical and experimental determination of cutting forces, dynamometers for measuring cutting forces, cutting temperature-causes, effects, assessment and control, cutting fluid application.

Machinability: Concept of machinability and its improvement, failure of cutting tools and tool life, cutting tool materials of common use, advanced cutting tool materials.

Introduction to various machine tools: Basic mechanism and operations of lathe, drilling, milling machines; working principle and applications of shaping, planning and slotting machines; estimation of machining time and tool life in metal cutting.

Finishing processes: Basic principle, purpose and application of grinding, selection of wheels and their conditioning, classification of grinding machines and their uses, super finishing processes, honing, lapping.

Screw threads and gear manufacturing methods: Production of screw threads by machining, rolling and grinding, manufacturing of gears.

Non-conventional machining: Classification of non-conventional machining based on energy type, abrasive jet machining, water jet and abrasive water jet machining, ultrasonic machining, electro chemical machining, electro discharge machining, electron beam and laser beam machining.

C. Text Books:

1. Rao, P. N., Manufacturing Technology: Foundry, Forming and Welding, Volume II, 4th Ed., 2018, Tata McGraw Hill.
2. Lal, G. K., Introduction to Machining Science, 3rd Ed., 2007, New Age International Pvt. Ltd..
3. Pandey, P. and Shan, H., Modern Machining Processes, 2017, McGraw Hill.
4. Shaw, M. C., Metal Cutting Principles, 2nd Ed., 2004, MIT Press.
5. Mishra, P. K., Non-conventional Machining, 1997, Narosa Publishing House.

D. Reference Books:

1. Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, 6th Ed., 2018, Pearson education.
2. Ghosh, A. and Mallik, A. K., Manufacturing Science, 1986, Wiley Eastern.

E. Course Outcomes: Upon completion of this course, the students will be able to:

1. Understand the basic concepts of manufacturing processes and operations along with non-traditional machining.
2. Understand and compare the functions and applications of different metal cutting tools.

3. Explain the operations and capabilities of machine tools used in manufacturing.
4. Analyse the different finishing and super finishing processes.

Name of the Module: Mechanical Laboratory-II
Module Code: ME-306
Credit Value: 1 [L=0, T=0, P=2]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To identify and distinguish the particle size of a given sand sample.
2. To calculate the average grain fineness number by sieving/ screening.
3. To analyse the friability value and moldability index of the molding sand.
4. Demonstrate laboratory techniques including the proper use of relevant instruments for measurement of various physical quantities.
5. To acquire a skill of design, drafting and analysis of permanent and non-permanent joints by using design software.
6. To acquire a skill of design and drafting of standard springs, understand its analysis by applying forces by using software and its comparison with analytical result.

B. List of Experiments:

Manufacturing Technology:

1. Sieve analysis test of sand/powder and its specification.
2. To find the distribution of sand grains using a set of sieves and to find the average grain fineness number.
3. To find the friability value and the moldability index of the compacted moulding sand.
4. To find the green compression strength of the given specimen at different percentage of clay and moisture.

Metrology:

5. Calibration of micrometer and Vernier caliper using slip gauges. Measurement of the diameter and height of a given specimen using the micrometer.
6. Use different angle measuring instruments.
7. Measurement of screw thread parameters using grove micrometer, checking the flatness of granite surface plate using spirit level.
8. Measurement of different elements of gear.

Machine Design-I

9. Design and Analysis of Mechanical components using AutoCAD/Solid works/CATIA/ANSYS:
10. Design and analysis of Permanent joints (Riveted Joints, Welded Joints).
11. Design and Analysis of temporary joints (Knuckle joints, Cotter joints, Nut and bolts).
12. Design and Analysis of shafts, couplings and springs.

C. Reference Books:

1. *Rao, P. N., "Manufacturing Technology: Foundry, Forming and Welding, Volume I", 5th Ed., 2018, Tata McGraw Hill.*

2. *Shigley, J. E., Mischke, C. R., "Mechanical Engineering Design", 9th Ed., 2018, Mcgraw Hill.*
3. *Holman, J. P., "Experimental Methods for Engineers", 7th Ed., 2017, McGraw Hill Education.*
4. *Jain, R. K., "Engineering Metrology", 21st Ed., 1984, Khanna Publishers.*

D. Course Outcomes: Upon completion of this course, the students will be able to:

1. Know basic principles of identification of particle grain size and the average grain fineness number by sieving/ screening technique.
2. Analyse the friability and moldability index of the moulding sand.
3. Identify the various parts of machine tools and different measuring instruments.
4. Measure different elements of gear and parameters like diameter, height angle etc.
5. Develop skill to apply knowledge of design software for design of permanent and non-permanent joints, shaft and springs.

Name of the Module: Mechanical Laboratory-III
Module Code: ME-307
Credit Value: 1 [L = 0, T = 0, P = 2]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To know the impact of jet on different surfaces.
2. To gain knowledge in performance testing of Hydraulic Turbines and Hydraulic Pumps at constant speed and Head.
3. To equip students with understanding of the fundamental principles and techniques for Identify different types of dynamic systems and classify them by their governing equations.
4. To develop equations of motion for translational and rotational mechanical systems.
5. To study the various parts of machine tools and understand the dynamics of machining by varying parameters.
6. To understand the influence of tool geometry and cutting tool materials on the performance of finished products.

B. List of Experiments:

<u>Fluid Mechanics-II</u>

1. Jet impact on flat and curved surfaces
2. Series and Parallel Connected Pumps to plot pump
3. Turbine to study their working and flow characteristics.

<u>Dynamics of Machinery</u>

4. Gyroscope and jump speed of a cam.
5. Whirling of shaft.
6. Mechanical vibrations.
7. Balancing.
8. Governors

<u>Machining processes:</u>

9. To fabricate, grind and measure the various tool angles for single point cutting tool.
10. To identify and determine the various cutting forces while machining in lathe, drilling, milling and other machining processes.
11. To measure the surface roughness of various machined surfaces using surface roughness tester.

C. Reference Books:

1. *Som, S. K.,. Biswas, G and Chakraborty, S., "Introduction to Fluid Mechanics and Fluid Machines", 3rd Ed., 2017, TMH.*
2. *Rattan, S. S., 'Theory of Machines' 5th Ed., 2019, TMH.*
3. *Ghosh, A., Mallik, A. K., "Manufacturing Science", 2nd Ed., 2010, Wiley Eastern.*

D. Course Outcomes: Upon completion of the experiments, students should be able to:

1. Understanding the working principles of hydraulic turbine, pump, gyroscope and cam.
2. Evaluate the impact of jet on different surfaces.
3. Illustrate the fundamental principles of vibrations and balancing.
4. Distinguish different types of Governors.
5. Selection of appropriate process parameters for various manufacturing operations.

Semester-VI

Name of the Module: Industrial Engineering & Operation Research
Module Code: ME-321
Credit Value: 4 [L = 3, T = 1, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To gain an understanding and appreciation of the principles and applications relevant to the planning, design, and operations of manufacturing/service firms.
2. To develop skills necessary to effectively analyze and synthesize the many inter-relationships inherent in complex socio-economic productive systems.
3. To gain some ability to recognize situations in a production system environment that suggests the use of certain quantitative methods to assist in decision making on operations management and strategy.

B. Course Content:

Introduction: Concept of Industrial Engineering, its role & applications, work study: time & motion study, Method study , Principles of motion economy, Workplace layout, Stopwatch time study, SIMO chart, Man-machine chart, Therbligs, PMTS, MTM, Work sampling. Organisation: Organisation structures, Types, Principles of organization structures, Features of various Ownerships, Company formations, its management and finance, Public limited & private limited company.

Material Management: Functions of material management, Inventories- its types, Just In Time (JIT) inventory, Concept of EOQ & EBQ, Simple EOQ model with and without stock outs, Simple EOQ model with varying demand and production, P- type & Q- type of inventory policies, Selective inventory control like ABC, VED, SDE techniques etc.

Production Planning &Control: Functions and role, Value analysis, Exponential smoothing constant and moving average method in demand and production forecasting, Break even analysis.

Quality Management: Quality v/s reliability, Quality maintenance and quality assurance, SQC technique, Acceptance sampling, Concept of TQM, ISO Standards.

Plant Layout: Location factors, Principles and design, Types of layout, Tools & technique.

Plant Maintenance: Break down, Scheduled and Preventive maintenance, Steps in preventive maintenance, TPM concept.

Operational Research: Concept of O. R, Methods of O.R, Concept of optimization, Linear programming, simplex method Transportation problem, Queuing theory. Decision theory, Integer programming, Revised simplex method, network techniques (PERT & CPM), theory of games, Simulation.

C. Text Books:

1. *Barnes, R. M., 'Motion and Time Study: Design and measurement of work' 7th Ed., 1980, Wiley.*
2. *Chary, S. N., 'Problems & Solutions in Production and Operations Management', 1st Ed., 1995, TMH.*
3. *Mahajan, M., 'Industrial Engineering and Production Management', 1st Ed., 2015, Dhanpat Rai and Co.*
4. *Taha, H. A., 'Operations Research- An Introduction', 9th Ed., 2014, Pearson.*

D. Course Outcomes: Upon completion of the subject, the students should be able to:

1. Identify the core features of the operations and production management function at the operational and strategic levels.
2. Identify and observe the operational research models from the description of a real system.
3. Illustrate the mathematical tools that are needed to solve optimization problems.
4. Develop an integrated framework for strategic thinking and decision making focusing wealth creation processes.

Name of the Module: Heat and Mass Transfer
Module Code: ME-322
Credit Value: 4 [L = 3, T = 1, P = 0]

A. Course Objectives: The course is designed to meet the following objectives:

1. To introduce a basic study of the phenomena of heat and mass transfer.
2. To develop methodologies for solving a wide variety of practical engineering problems.
3. To design a knowledgeable based problem requiring the formulations of solid conduction and fluid convection.
4. To develop basic understanding of two phase flow heat transfer.

B. Course Content:

Introduction: Typical heat transfer situations, Modes of heat transfer, Introduction to laws, some heat transfer parameters.

Conduction: Fourier's law and thermal conductivity, Equation of heat conduction, Boundary conditions and Initial conditions**,** One dimensional steady state situations **–** plane wall, cylinder, sphere, Concept of thermal resistance, Concept of overall heat transfer coefficient, Critical radius, Heat generation**,** Fin analysis- Uniform cross section, Two dimensional steady heat conduction.

Transient conduction-Lumped capacitance model, One dimensional transient conduction – analytical solutions.

Forced convection: Concepts of fluid mechanics, Differential equation of convection**,** Laminar flow and heat transfer in circular pipe, Thermal entrance region, Turbulent flow heat transfer.
Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere, flow across banks of tubes.

Natural convection: Introduction, Differential equations, Vertical plate, Horizontal cylinder, Horizontal plate.

Heat exchangers: Types of heat exchangers, LMTD-NTU approach – parallel and counter-flow arrangements.

Boiling and condensation: Dimensionless parameters, boiling modes, correlations, Forced convection, laminar film condensation on a vertical plate.

Mass transfer: Analogy between heat and mass transfer, mass diffusion, Fick's law of diffusion, boundary conditions, steady mass diffusion through a wall, Mass convection.

C. Text Books:

1. *Incropera, F. P., Dewitt, D. P., Bergman, T. L., "Introduction to Heat Transfer", 5th Ed., 2006, John Wiley & Sons.*
2. *Bejan, A., "Convection Heat Transfer", 3rd Ed., 2006, John Wiley.*
3. *Ozisik, M. N., "Heat Conduction", 3rd Ed., 2012, John Wiley & Sons.*

D. Course Outcomes: Upon completion of the subject, students should be able to:

1. Define the different modes of heat transfer and basic laws of heat as well as mass transfer.
2. Understand the fundamentals of convective heat transfer process.
3. Calculate the consequences of heat transfer in thermal analyses of engineering systems.
4. Solve problems involving steady and transient heat conduction in simple geometries.
5. Analyse heat exchanger performance and effectiveness as well as boiling heat transfer.

Name of the Module: Machine Design - II
Module Code: 323
Credit Value: 4 [L = 3, T = 1, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To understand the design and analysis of clutches, brakes and fly wheels.
2. To determine the forces on different type of gears for power transmission.
3. To determine the different forces acting on bearings and understanding selection of bearings.

B. Course Content:

Design of Clutches, Brakes and Flywheels: Brakes and clutches need and functioning, design of disc and cone type of clutches for uniform pressure and wear. Design of internal expanding and external contracting

brakes, band type of brakes, cone and disk brakes. Flywheel: coefficient of fluctuation of speeds, fluctuation of energy, energy stored in flywheel, stresses in flywheel ring and arms.

Design of gear: Gears types and application and gear terminology, Law of gearing-conjugate action and interference in gears, Analysis of forces on spur, and helical gears, Bending and contact stress in gear tooth-Lewise equation for design, Dynamic loading and wear-Buckingham equations for design. Force analysis on bevel and worm gears, Design approach for bevel gears-equivalent tooth, Design of fixed ratio gear box-general design procedure.

Sliding and Journal Bearing: Types of lubrication, hydro static and dynamic lubrication. Petroff's equation and the bearing characteristic number, Lubrication regimes-boundary and film lubrication, Hydro dynamic bearings-Pressure distribution-eccentricity and minimum film thickness Reynolds equation and use of bearing design charts, Heat generation and thermal equilibrium.

Rolling Contact Bearing: Types of ball bearing, Thrust ball bearing, Types of roller bearing,
Selection of radial ball bearing, Bearing life, Selection of roller bearings, Dynamic equivalent load for roller contact bearing under constant and variable loading, Reliability of Bearing. Selection of rolling contact bearing.

Design of IC Engine Components: General design consideration, design of cylinder, cylinder liner, cylinder head, pistons, connecting rod and crank shaft.

C. Text Books*:*

1.Norton, L. R, "Machine Design", 5th Ed., 2018, Pearson Education Asia.
2.Spotts, M. F. and Shoup, T. E., "Design of Machine Elements", 8th Ed., 2006, Prearson Hall.
3.Shigley, J. E. and Mischke. C. R., "Mechanical Engineering Design", 10th Ed., 2014, Mcgraw Hill.
4.Bhandari, V. B., "Design of Machine Elements", 4th Ed., 2017, McGraw-Hill.

D. Reference Book:

1.Juvinal, R. C. and Marshek, K. M., "Fundamentals of Machine Component Design" 5th Ed., 2016, John Wiley Publication.

E. Data Book:

1. *"Design Data: Data Book of Engineers",* 2012, *PSG College of Technology, Coimbatore.*
2. *S.Md.Jalaludeen, "Design Data Hand Book –Mechanical & Automobile", 3rd Ed, 2016, Anuradha Agencies Kumbakonam.*
3. *Maitra, G.M. and Prasad, L.V., "Handbook of Mechanical Design", 1985, McGraw-Hill Inc.*
4. *Mahadevan, K. and Balaveera, K. Reddy, "Design Data Handbook for Mechanical Engineering" 4th Ed., 2013, CBS Publishers.*

F. Course Outcomes: Upon completion of the subject, students should have the knowledge of:

1. Basic understanding and selection of clutch, brakes and flywheel for power transmission.
2. Study the design process of gears based on the given load conditions.
3. Basic understanding with selection of bearings for a given applications from the manufacturers catalogue.
4. Apply knowledge learnt for design various components for given applications.
5. Use of computerized tools for 3D design of machine elements.

Name of the Module: IC Engines
Module Code: 324
Credit Value: 4 [L = 3, T = 1, P = 0]

A. Course Objectives: The subject is designed to meet the following objectives:
1. To learn about various parts associated with IC engines.
2. To understand the basics of IC engines.
3. To understand combustion principles, parameters and variables affecting IC engines.
4. To learn about various systems used in IC engines and the types of IC engine required for various applications.
5. To learn about emission and its control.

B. Course Content:
Introduction: Engines, Classifications & Construction of IC Engines, Engine performance parameters, review of air-standard cycles, fuel-air cycles, actual cycles and their analysis, SI and CI engine fuels, alternate fuels.

Carburetion: Factors affecting carburetion, Air-fuel mixtures, The simple carburettor, Essential parts of modern carburetors, Calculation of Air Fuel Ratio, Working of various carburettors.

Combustion in S.I. Engines: Stages, Flame Propagation, Factors Influencing the Flame Speed, Rate of Pressure Rise, Ignition Delay, Knocking .

Fuel Injection and Mixing: Air & Solid Injection, Fuel Feed pump, Injection Pumps, fuel injector, Nozzles, Injection in SI engine, Mechanical and Pneumatic Governor, Spray Characteristics, Swirl, Squish and Tumble, electronic fuel injection system, MPFI, Injection Timing.

Ignition system: Introduction, classification, components of ignition system, modern ignition systems.

Combustion in C.I. Engines: Stages, Injection Delay, Factors Influencing the Delay, Knocking, Effect of Variables on Knocking.

Cooling and Lubrication System: Introduction, Need and type of cooling system, Air and Liquid Cooling, Thermo syphon, Pressure Cooling, Engine Friction, Function and Mechanism of Lubrication, lubrication systems, properties of lubricant.

Supercharging & Turbocharging: Supercharging, Methods of Supercharging, turbocharging, Charge Cooling.
Nonconventional Engines: CRDI engine, Dual Fuel and Multi Fuel Engines, Free Piston Engines, Wankel and Stirling Engines, VCR Engine, PFI & GDI Engines.

Measurement and Testing: Tests for Friction Power, Indicated Power, Brake Power, Fuel Consumption, Air Consumption.

Emissions and Control: Introduction, Emission norms, Engine emissions, Emission control methods.

C. Text Books:

1. Ganesan, V., Internal Combustion Engines, 4th Ed., 2017, Tata McGraw-Hill.

D. Reference books:

1. Fergusan, C. R. and Kirkpatrick, A. T., Internal Combustion Engines, 2nd Ed., 2001, John Wiley & Sons.

2. Stone, R., Internal Combustion Engines, 4th Ed., 2012, The Macmillan Press Limited.

E. Course Outcome: After studying this course, students will be able to:

1. Demonstrate the basics of IC engines and how different parameters influence the operational characteristics of IC Engines.
2. Understand Ignition and combustion in SI, CI and non-conventional engines.
3. Calculate difference performance parameters.
4. Analyse the exhaust emission and learn about its control strategies.

Name of the Module: Computer Aided Design and Manufacturing
Module Code: ME-325
Credit Value: 3 [L=3, T=0, P=0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To introduce the students to the basic tools of Computer Aided Design (CAD).
2. To enable students to carry out all 2D and 3D designs using CAD package.
3. To introduce the students to the standard terminologies, design and operational characteristics of Numerical Control (NC) and Computer Numerical Controlled (CNC) machines.
4. To prepare the students to be an effective user of a CAD/CAM system.

B. Course Content:

Introduction: Fundamentals of CAD, automation, design process, application of computers for design, benefits of CAD, computer configuration for CAD applications.

Geometric modeling: 3D wire frame modelling, wire frame entities and their definitions, interpolation and approximation of curves, concept of parametric and non-parametric representation of curves, curve fitting techniques, Cubic spline, Bezier and B-spline.

Surface modelling: Algebraic and geometric form, parametric space of surface, blending functions, cylindrical surface, ruled surface, composite surface, Bezier surface, B-spline surface, solid modelling, cell composition, constructive solid geometry, boundary representations.

Basic concepts of graphics programming: Transformation matrix, graphical user interface (GUI).

NC/CNC control production systems: NC control, elements of NC system, NC part programming, methods of NC part programming, manual part programming, computer assisted part programming, CNC programming, adaptive control systems.

Computer Aided Manufacturing: Computer aided process planning, manufacturing resource planning, flexible manufacturing system and computer aided quality control and computer integrated manufacturing.

C. Text Books:

1. *Ibrahim, Z., CAD/CAM: Theory and Practice, 1991, TMH.*
2. *Rao, P. N., CAD/CAM: Principles and Applications, 3rd Ed., 2017, TMH.*
3. *Groover, M. and Zimmers,E., CAD/CAM: Computer Aided Design and Manufacturing, 1983, Prentice Hall.*
4. *Alavala, C. R., CAD/CAM: Concepts and applications, 2008, PHI Learning Pvt. Ltd.*
5. *Lee, K., Principles of CAD/ CAM/ CAE, 1st Ed., 1999, Addison Wesley.*

D. Reference Books:

1. *Valentino, J. V. and Goldenberg, J., Introduction to Computer Numerical Control, 5th Ed., 2012, Prentice Hall, Englewood Cliff, New Jersey.*
2. *Gibbs, D. and Crandall, T., CNC Machining and Programming: An Introduction, 2003, Industrial Press Inc.*

E. Course Outcomes: Upon completion of this course, the students will be able to:

1. Recognize the geometric transformation techniques in CAD.
2. Distinguish NC, CNC and DNC systems and understand the basic principles of CAM, FMS and CIM.
3. Apply mathematical tools to represent curves and surfaces for engineering applications.
4. Develop manual and APT part programs for various profiles and test the program through simulation.

Name of the Module: Mechanical Laboratory-IV
Module Code: ME-326
Credit Value: 1 [L = 0, T = 0, P = 2]

A. Course Objectives: The laboratory course is aimed to:

1. Define the fundamental concepts to students in the area of heat transfer and its applications.
2. Recognize the practical significance of various parameters involved in different modes of heat transfer.
3. To acquire a skill of design, drafting and analysis of bearings and gears using design software and comparing with analytical results.
4. To acquire skill of design, drafting and analysis of IC engine parts using design software and comparing with analytical results.
5. To demonstrate and develop understanding among the students about the basic working principles of refrigeration and air conditioning with hands-on experience and demonstrates the basics of psychometry.

B. List of Experiments:

Heat Transfer

1. Determination of thermal conductivity through composite wall during steady state heat conduction.
2. Determination of thermal conductivities of various fluids at different temperatures during steady-state heat conduction in gases and liquids.

3. Measuring the heat transfer rates, coefficients, Reynolds and Nusselt numbers for free and forced convection through flat plate, pipe bundle and fins.
4. Determination of mean heat transfer coefficients in parallel flow, counter flow, shell and tube heat exchanger.
5. Determination of Stefan-Boltzmann constant experimentally.

Machine Design-II

6. Design and Analysis of bearings.
7. Design and Analysis of Gears.
8. Design of IC engine parts (Cluthes, Fly Wheels, Connecting Rods, Crank Shafts, Pistons, Cylinders and Cylinder heads.

Refrigeration and Air Conditioning

9. Understanding the operation of key components of a vapor compression refrigeration system (compressor, evaporator, condenser, and expansion element) and the cycle. Performing the energy balance.
10. Studying the basic principle of an absorption refrigeration system under various loads.
11. Studying the basic principle of an air conditioning system under various loads.

C. Reference Books:

1. *Incropera, F. P., Dewitt, D. P., Bergman, T. L., "Introduction to Heat Transfer", 5th Ed., 2006, John Wiley & Sons.*
2. *Shigley, J. E. and Mischke. C. R., "Mechanical Engineering Design", 10th Ed., 2014, Mcgraw Hill.*
3. *Arora, C. P., "Refrigeration and Air Conditioning", 3rd Ed., 2017, Tata McGraw-Hill.*

D. Course Outcomes: Upon the completion of this course the student will be able to:

1. Define and determine thermal conductivity and convective heat transfer coefficient.
2. Define and construct the Mechanical Engineering parts and components which include gears, bearings, IC engine parts along with their assembly drawing and analysis.
3. Knowledge of refrigerant compressors, evaporator, condenser, and expansion devices used in vapour compression refrigeration system.
4. Understand the principles and applications of vapour compression, vapour absorption refrigeration systems and basics of psychometry.
5. Verify Stefan Boltzmann law.

Name of the Module: Mechanical Laboratory-V
Module Code: ME-327
Credit Value: 1 [L = 0, T = 0, P = 2]

A. Course Objectives:

1. To understand the basic internal combustion engine performance, brake power, Indicated power, friction power and volumetric efficiency of I.C. engines.
2. To develop an idea of fuel properties and their variation with temperature, determination of kinematic viscosity and calorific value of fuel.

3. To provide practical experience with an opportunity of hands-on training on modern CNC machines and CIM system.
4. To provide the basis of NC programming (manual and APT) and CNC programming.

B. List of Experiments:

I.C Engine:

1. Study the working principle of Two-Stroke Internal Combustion Engines.
2. Study the working principle of Four-Stroke Internal Combustion Engines.
3. To Determine the Brake power (kW), Brake mean effective pressure (bar), Indicated power (kW), Indicated mean effective pressure (bar), Frictional power (kW), Brake specific fuel consumption (kg/kWh), Brake Thermal Efficiency (%), Indicated Thermal Efficiency (%), Mechanical Efficiency (%), Air flow (kg/hr), Volumetric Efficiency (%), Mechanical Efficiency of a Single Cylinder Four-Stroke Diesel Engine.
4. Determination of Viscosity, Calorific value, Flash points and Fire points, Aniline point of liquid fuels.

CAM/CIM:

5. Write a part program for Linear and Circular Contour (G01, G02 and G03) operation for the component.
6. Write a part program for Multiple Facing (G72) operation for the component.
7. Write a part program for Multiple Turning operation with G71 cycle for the component.
8. Write a part program for Turning and Parting OFF operation through subroutines for the component.
9. Write a part program for Contouring (G01, G02 and G03) operation (Linear & Circular Interpolation) for the component.
10. Write a part program for Contouring (G40, G41) operation with Left cutter diameter compensation for the component.
11. Write a part program for Drilling (G73, G83, G98 and G99) operation for the component.
12. Demonstration and study of CIM system off-line/ on-line manual mode.

C. Reference Books:

1. *Ganesan, V., Internal Combustion Engines, 4th Ed., 2017, Tata McGraw-Hill.*
2. *Valentino, J. V. and Goldenberg, J., Introduction to Computer Numerical Control, 5th Ed., 2012, Prentice Hall, Englewood Cliff, New Jersey.*

D. Course Outcomes: Upon the completion of this course the student will be able to:

1. Explain the complete operation of 2 stroke and 4 stroke I.C engines and its performance evaluation.
2. Knowledge and operational experience of CNC lathe and milling part programming.
3. Calculate viscosity, flash points, fire points, aniline point and calorific value of fuel.
4. Capability to comprehend the functioning of various components of the automation and CIM.

Semester-VII

Name of the Module: Mechatronics
Module Code: 401

Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

1. Generate conceptual design for Mechatronics systems based on potential customer requirements.
2. Selection of appropriate sensors and transducers and devise an instrumentation system for collecting information about processes, control systems.
3. Design a control system for effective functioning of Mechatronics systems using digital electronics, microprocessors, microcontrollers and programmable logic controllers.
4. Selection of appropriate actuators for physical systems.
5. Study design of robot as case study.

B. Course Content:

Introduction: Introduction to Mechatronics, need and applications, Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modeling, Analysis and Simulation, Man Machine Interface; , role of mechatronics in automation, manufacturing and product development.

Sensors and transducers: characteristics, classification, working principles, Development in Transducer technology, Opto-electronics Shaft encoders, strain, velocity , Acceleration, LVDT, temperature Sensors, Vision System, etc.

Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems;

Smart materials: Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators, Micro-sensors, Micro-actuators;

Application: Case studies based on the application of mechatronics in manufacturing, Machine Diagnostics, Road vehicles and Medical Technology, bionics and avionics. Industrial robotics, types of Industrial robots, classification based on work envelope, Generations configurations and control loops, co-ordinate systems, need for robot, basic parts and functions, specifications.

C. Text Books:

1. *Bolton, W., "Mechatronics, Electronic control systems in mechanical and electrical engineering", 5th Ed., 2011, Pearson Education.*
2. *Alcaiatore, G.D., Michel B. H., "Introduction to Mechatronics and Measuring Systems", 3rd Ed., 2006, Mc. Graw Hill International.*
3. *Robert H. B., "The Mechatronics Handbook", 2nd Ed., 2007, CRC Press.*

D. Reference Books:

1. *Stenersons, J., "Fundamentals of Programmable Logic Controllers Sensors and Communications", 3rd Ed., 2004, Pearson Education.*
2. *Kuttan K. A., "Introduction to Mechatronics", 2007, Oxford University Press.*

E. Course Outcomes:

Students who successfully fulfil the course requirements will:

1. Be able to identify the need of mechatronics and integrated product design procedure and role of mechatronics in various engineering fields.

2. Have basic understanding of various types of sensors and transducers including modelling
3. Study and select appropriate actuators and drivers along with design of control system and modelling.
4. Have case studies and design of robotic systems and application of mechatronic in system design.

ELECTIVES

Name of the Module: Refrigeration and Air-conditioning
Module Code: 402A
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet the following objectives:
1.Learning the fundamental principles and different methods of refrigeration and air conditioning.
2.Study of various refrigeration cycles and evaluate performance using p-h charts and/ or refrigerant property tables.
3.Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
4.Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems.

B. Course Content:
Introduction: Brief history and need of refrigeration and air conditioning, methods of producing cooling, ton of refrigeration, coefficient of performance, types and application of refrigeration and air condensing systems.

Refrigerants: Classification, nomenclature, desirable properties, secondary refrigerants, future industrial refrigerants.

Air refrigeration: Reversed Carnot cycle and its limitation, Bell-Coleman cycle, aircraft refrigeration, working and analysis of simple; Bootstrap; Reduced ambient and Regenerative air refrigeration systems.

Vapour compression Refrigerating (VCR) system: Reverse Carnot cycle and its limitations, Simple VCR system and its performance analysis, Factors affecting the performance of cycle, Actual cycle, Compound Compression System, Multiple evaporators system, Cascade refrigeration system.

Vapour absorption system: Desirable characteristics of refrigerant, selection of pair, practical H_2O -NH_3 cycle, LiBr – H2O system and its working, Electrolux refrigeration system.

Refrigeration system components: Compressors-reciprocating and axial, Condensers and evaporators, Expansion devices.

Psychometry: Air properties and psychometric chart, Sensible heating, Sensible cooling, Humidification, Dehumidification and their combinations, Bypass factor, Sensible heat ratio, Comfort, Psychometric calculations for cooling, Evaporative cooling.

Summer and winter air conditioning: Simple summer air conditioning process, room sensible heat factor, coil sensible heat factor, ADP, winter air conditioning, comfort zone, clothing.

Load analysis: Internal heat gain, system heat gain, break-up of ventilation load and effective sensible heat factor, cooling load and heating load estimation.

C. Text Books:

1. *Arora, C. P., "Refrigeration and Air Conditioning", 3rd Ed., 2017, Tata McGraw-Hill.*
2. *Stoecker, W. F., "Refrigeration and Air Conditioning", 2nd Ed., 2014, Tata McGraw-Hill.*

D. Reference Books:

1. *Dossat, R. J., "Principles of Refrigeration", 4th Ed., 2002, Pearson Education.*

E. Course Outcomes: Upon completion of the subject, students should be able to:

1. Define the fundamental principles and applications of refrigeration and air conditioning system.
2. Explain the properties, applications and environmental issues of different refrigerants.
3. Calculate cooling capacity and coefficient of performance of air refrigeration system, VCRS and VARS.
4. Use P-h, T-S and Psychometric charts to solve refrigeration and Air conditioning design problems.

Name of the Module: Conduction and Radiation
Module Code: 402B
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

The objectives of the course is:

1. To familiarize the students with the fundamental concepts of heat transfer.
2. To introduce a basic study of the phenomena of conduction and radiation to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes.
3. To impart knowledge related to design problem requiring the formulations of solid conduction and the technique of numerical computation.

B. Course Content:

Introduction to conduction- Recapitulation: Steady and Transient conduction; Fins, Lumped parameter and semi-infinite solid approximations, Heisler and Grober charts; 3-D conduction, isotropic, orthotropic and anisotropic solids**.**

Analytical methods- Mathematical formulations, analytical solutions, variation of parameters, integral method, periodic boundary conditions, Duhamels theorem and Greens function.

Numerical method- 2-D conduction problems without and with heat generation.

Introduction to radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Spectral and directional variations, View factors.

Enclosure with transparent medium- Enclosure analysis for diffuse-gray surfaces and non-diffuse, non-gray surfaces, net radiation method.

Enclosure with participating medium- Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation.

C. Text Books:

1. *Myers, G. E., "Analytical Methods in Conduction Heat Transfer", 1987, McGraw-Hill.*
2. *Modest, M. F., "Radiative Heat transfer", 3rd Ed., 2013, Academic Press.*
3. *Ozisik, M. N., "Heat Conduction", 2nd Ed., 1993, John Wiley & Sons.*

D. Reference Books:

1. *Vedat S. A., "Conduction Heat Transfer", 1987, Addison-Wesley.*
2. *Incropera, F. P., Dewitt, D. P., Bergman, T. L., "Introduction to Heat Transfer", 5th Ed., 2006, John Wiley & Sons.*
3. *Siegel, R. and Howell, J. R., "Thermal Radiation Heat Transfer", 4th Ed., 2002, Taylor & Francis.*

E.Course Outcomes: The course is intended to provide students with the following benefits:

1. Explain problems involving steady and transient heat conduction.
2. Formulate analytical as well as numerical solutions for heat transfer problems.
3. Understanding of basic radiation heat transfer.
4. Investigate radiation heat transfer in transparent and participating media.

Name of the Module: Advanced Fluid Mechanics
Module Code: 402C
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

This course is designed to:

1. Introduce fundamental aspects of fluid flow behaviour.
2. Learn to develop steady state mechanical energy balance equation for fluid flow systems.
3. Estimate pressure drop in fluid flow systems.

B. Course Content:

Introduction- Review of fundamental Concepts, Eulerian and Lagrangian methods of description of fluid flow; Reynolds transport equation, basic equations of motion of fluid flow, Equation of continuity, Navier-Stokes equationsand boundary conditions; Non-dimensionalization of equations and order of magnitude analysis, Euler's equations, Bernoulli's equation, dimensionless parameters and their significance, Exact solution of incompressible Navier-Stokes equations- plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders.

Potential flows- Stream and Velocity potential function, Circulation, Irrotational vortex, Source and Sink, Vortex flow, Doublet, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag.

Boundary layer theory- D' Alemberts paradox, Prandtl's boundary layer equations, Von Karman's momentum integral equations, Blasius solution, approximate methods, transition and turbulent flows, turbulent boundary layer, instability and transition.

Compressible flow- Isentropic flow; flow with area change; normal shock waves; oblique shock wave, one and two dimensional compressible flows, compressible viscous flows, compressible boundary layers.

C. Text Books:

1. *Munson, B. R., Young, D. F., Okiish, T. H., "Fundamental of Fluid Mechanics", 6th Ed., 2009, Wiley.*
2. *White, F., "Fluid Mechanics", 8th Ed., 2017, TMH.*

D. Reference Books:

1. *Fox, R. W., McDonald, A. T., Pritchard, P. J., "Introduction to Fluid Mechanics", 6th Ed., 2003, Wiley.*
2. *Anderson, J., Modern Compressible Flow, 3rd Ed., 2017, TMH.*
3. *White, F. M., "Viscous Fluid Flow", 3rd Ed., 2017, McGraw-Hill Education.*
4. *Schlichting, H., "Boundary Layer Theory", 2011, Springer.*

E. Course Outcomes:

Upon completion of the subjects, the student should:

1. Understand the concept of fluid and the models of fluids and the physical meaning of general equations.
2. Develop the concept of stream function and potential function
3. Formulate the equation for viscous flow, including laminar flow and turbulent flow.
4. Apply the compressible flow analysis to a pipe flow and compute the pressure losses due to friction, area change in the system and assess the performance of the system.

Name of the Module: Gas Turbine Technology
Module Code: 402D
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

1. This course is designed to have an advanced understanding of the theory and operation of gas turbine engines.
2. To apply thermodynamic principles to calculate parameters such as pressure and temperature in Gas Turbine Engines as used in aircraft.

B. Course Content:

Fundamentals of turbo machines- Classification, Applications, Isentropic flow, Energy transfer, Efficiency, static and Stagnation conditions, continuity equation, Euler's flow through variable cross sectional area, unsteady flow in turbo machine.

Gas dynamics- Fundamentals, thermodynamic concepts, Isentropic conditions, Mach number and Area – Velocity relation, Dynamic pressure, normal shock relations for perfect gas, supersonic flow, oblique shock waves.

Centrifugal compressors- Elements of compressor stage, Velocity triangles and efficiencies, Blade passage design, Diffuser and pressure recovery, slip factor, Compressor performance - Stall and surge, Performance characteristics.

Axial flow compressors- Flow analysis, work and velocity triangles, Efficiencies, Thermodynamic analysis, stage pressure rise, Degree of reaction, stage loading, Free and forced vortex blades, Effect of axial velocity and incidence on velocity triangles, Performance characteristics.

Axial flow gas turbines- Work done; velocity triangles and efficiencies; thermodynamic flow analysis, degree of reaction, Free-vortex blades, Blade angles for variable degree of reaction, Matching of compressor and turbine.

C. Text Books:

1. *Breeze, P., "Gas-Turbine Power Generation", 2016, Academic Press.*
2. *Ganesan, V., "Gas Turbines", 3rd Ed., 2017, Tata McGraw-Hill.*

D. Reference Books:

1. *Saravanamuttoo, "Gas Turbine Theory", 5th Ed., 2006, Pearson Education.*

E. Course Outcomes:

Students will be able to:

1. Describe the fundamentals of turbo machines as well as flow in turbo machines.
2. Analyse the conditions and concepts of gas dynamics at different levels.
3. Apply the thermodynamics of aircraft propulsion systems, air compressor and gas turbines.
4. Calculate velocity triangles, work done etc. for flow in gas turbine and air compressors.

Name of the Module: Turbomachinery
Module Code: 402E
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

The course is designed to:

1. Provide a thorough understanding of the principles and applications of turbomachinery in modern industry.
2. Analyse a useful tool for designing and researching on turbomachinery instruments.

B. Course Content:

Centrifugal fans and blowers - Types- stage and design parameters-flow analysis in impeller blades-volute and diffusers, losses, characteristic curves and selection, fan drives and fan noise.

Centrifugal compressor - Construction details, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.

Axial flow compressor - Stage velocity diagrams, enthalpy-entropy diagrams, stage losses and efficiency, work done simple stage design problems and performance characteristics.

Axial and radial flow turbines - Stage velocity diagrams, reaction stages, losses and coefficients, blade design principles, testing and performance characteristics.

C. Text books:

1. *Yahya, S. M., "Fundamentals of Compressible Flow", 6th Ed., 2018, New Age International (P) Limited.*
2. *Stepanoff, A.J., "Turboblowers", John Wiley & Sons.*

D. Reference Books:

1. *Church, A. H., "Centrifugal pumps and blowers", 1944, John Wiley and Sons.*
2. *Dixon, S. L. and Hall, C. A., "Fluid Mechanics and Thermodynamics of turbomachinery", 7th Ed., 2014, Pergamon Press.*

E. Course Outcomes:

Upon completion of the subject, the students should:

1. Understand the concept of fluid mechanics and thermodynamics in turbomachinery.
2. Describe the basic characteristics of radial and axial pumps, compressors, turbines and fans with different kinds of working mediums.
3. Determine performance of compressor and turbine.
4. Analyse the fluid mechanics responsible for limits of turbomachinery operability and stability, particularly, stall, surge, cavitations, and choke.

Name of the Module: Automobile Engineering
Module Code: 402F
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

1. Introduction to engineering analysis of the automobile and its sub-systems.
2. Application of engineering principles to automotive design.
3. Acquaintance with modelling and analysis methods.
4. Acquaintance with the automotive industry and its terminology.

B. Course Content:

Introduction: Main units of automobile chassis and body, different systems of the automobile, description of the main parts of the engine, motor vehicle act. Power for Propulsion Resistance to motion, rolling resistance, air resistance, gradient resistance, power required for propulsion, tractive effort and traction, road performance curves. Breaking systems Hydraulic breaking system, breaking of vehicles when applied to rear, front and all four wheel, theory of internal shoe brake, design of brake lining and brake drum, different arrangement of brake shoes, servo and power brakes.

Transmission Systems: Layout of the transmission system, main function of the different components of the transmission system, transmission system for two wheel and four wheel drives. Hotchkiss and torque tube drives.

Gear box: Sliding mesh, constant mesh and synchromesh gearbox, design of 3 speed and 4 speed gear box, over drive, torque converter, semi and fully automatic transmission. Hookes joint, propeller shaft, differential, rear axles, types of rear axles, semi floating, there quarter floating and full floating types.

Front wheel Geometry and steering systems: Camber, castor, kingpin inclination, toe-in and toeout, centre point steering condition for true rolling, components of steering mechanism, power steering.

Electrical system of an automobile: Starting system, charging system, ignition system, other electrical system. Electrical vehicles: History, electrical vehicles and the environment pollution, description of electric vehicle, operational advantages, present EV performance and applications, battery for EV, Battery types and fuel cells, Solar powered vehicles, hybrid vehicles.

C. Text Books:

1. *Giri, N. K., Automobile Mechanics, 1998, Khanna publishers.*
2. *Gupta, S. K., A text book of Automobile Engineering, 2nd Ed., 2020, S Chand*

D. Reference Books:

1. *Crouse, W. H. and Anglin, D. L., Automotive mechanics, 10th Ed., 2017, TMH.*
2. *Heitner, J., Automobile Mechanics, 2nd Ed., CBS Publishers & Distributors*

E. Course Outcomes: On successful completion of the course, the student will be able to:

1. Demonstrate the vehicle construction, chassis, lubrication system and cooling system in automobile, 3-way catalytic converter.
2. Identify the wheels, tyres, steering gear box, suspension system-telescopic, and leaf spring.
3. Describe the principles and working of Carburettors, CRDI, MPFI, electronic fuel injection system and Ignition system.
4. Differentiate between clutch, gear box, rear axle drives, fluid flywheel, and torque converter.
5. Appraise the recent trends in alternate fuels and automobile safety system.

Name of the Module: Fuels and Combustion
Module Code: 402G
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

1. To understand solid, liquid and gaseous fuel properties, analysis, process and handling
2. To know the stoichiometry relations and combustion process
3. To learn about features of different types of burners.
4. To understand about emissions.

B. Course Content:

Introduction: History of Fuels, classification, properties, Production, present scenario and consumption pattern of fuels.

Solid Fossil fuel (Coal): Definitions and properties, classification, Analysis- Proximate and ultimate, composition, preparation, combustion techniques, liquefaction, Gasification.

Liquid Fossil fuel (Petroleum): exploration, evaluation, Refining of Petroleum, cracking, Synthesis of Gasoline-Fischer-Tropsch process. And Bergius process, distillation, Hydro-treatment, dewaxing, deasphalting, Refining of Petroleum.

Gaseous Fuels: Natural gas, LPG, Producer gas, Water gas, Hydrogen, Acetylene and Other fuel gases.

Power alcohol and Biodiesel: Production of ethanol, Production of biodiesel, Flue Gas Analysis.

Combustion Technology: Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame-premixed and diffusion flames, Flame Properties, Combustion devices-Burners, Furnaces, Gasifiers, IC Engines, Nuclear Reactors.

Emissions: Emission index, corrected concentrations, control of emissions for premixed and non-premixed combustion.

C. Text Books:

1. *Turns, S., An Introduction to Combustion: Concepts and Applications, 3rd Ed., 2017, McGraw-Hill.*
2. *Sarkar, S., Fuels and Combustion, 3rd Ed., 2009, Universities Press.*

D. Reference Books:

1. *Glassman, I., Combustion, 3rd Ed., 1997, Academic Press.*
2. *Griswold,J., Fuels Combustion and Furnaces, 2006, Mc-Graw Hill.*

E. Course Outcomes:

The student will be able to:

1. Identify the types of fuels (solid, liquid and gas).
2. Understand design considerations of burners.
3. Develop the mechanism and kinetics of combustion principles.
4. Analyse exhaust and flue gases.

Name of the Module: Renewable Energy
Module Code: 402H
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: This course is designed to meet the following objectives:

1. To understand about energy systems and renewable energy resources.
2. To learn about scientific examination of the energy field with emphasis on alternative energy sources and their technology and application.

B. Course Content:

Introduction: Various non-conventional energy resources, potential of renewable energy sources, global as well as Indian scenario.

Solar energy: Solar radiation, measurement of solar radiation, solar thermal collector-flat plate and concentrating collector, solar applications, fundamentals of photo voltaic conversion, solar cells, solar pvs.

Wind energy: Principles of wind energy conversion, wind energy generators and its performance, wind energy storage, applications, hybrid systems.

Energy from bio-mass: Biomass, biogas, bio-mass conversion technologies, different types of bio gas plants, digesters, thermal gasification of biomass, ethanol production, bio diesel production and economics.

OTEC, tidal and wave, geothermal, hydel energy and hydrogen energy: Tidal energy, wave energy, ocean thermal energy conversion, open and closed OTEC cycles, hydro power energy, small hydro turbines, geothermal energy sources, production and storage of hydrogen energy, transport, applications, power plant and environmental issues, Energy storage.

M H D power generation: Principles of MHD power generation, open and closed cycle systems.
Energy storage: Fuel cell.

C. Text Books:

1. Godfrey, B., Renewable Energy, 2nd Ed., 2004, Oxford University Press
2. Schaeffer, J., Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living, 14th Ed., 2014, New Society Publishers

D. Reference Books:

1. Ristinen, R. A., Kraushaar, J., A., Brack, J., Energy and the Environment, 3rd Ed., 2015, John Wiley
2. Sukhatme, S. P. and Nayak, J. K., Solar Energy: Principles of Thermal Collection and Storage, 3rd Ed., 2009, McGarw-Hill.

E. Course Outcome: Upon successful completion of the course, the students will be able to:

1. Explain the main sources of energy and their primary applications.
2. Understand the energy sources and scientific concepts/principles behind them.
3. Analyse the effects of using energy sources on environment and climate.
4. Describe the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the impact on the environment.
5. Identify primary renewable energy resources and suitable technologies acting upon it.

Name of the Module: Computational Fluid Dynamics
Module Code: 402I
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

1. Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems.
2. Provide the essential numerical background for solving the partial differential equations governing the fluid flow.

B. Course Content:

Introduction to computational fluid dynamics and principles of conservation- Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations.

Classification of partial differential equations and physical behaviour- Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations.

Approximate solutions of differential equations- Error Minimization Principles, Functional involving higher order derivatives, Approximate solution of differential equations through variation formulation, Boundary conditions in the variation form: Primary and secondary variables, Essential and natural boundary conditions, Approximate solutions of differential equations, Properties of variation form, Weighted residual approach: trial function and weighting function, Requirement of trial function and weighting function, Least square method, Point Collocation method, Galerkin's method, Rayleigh-Ritz method.

Fundamentals of discretization- Discretization principles: Pre-processing, Solution, Post-processing, Finite Element Method, 3 Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term.

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 conditions.

Discretization of unsteady state problems- 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme.

Finite volume discretization of 2-d unsteady state diffusion type problems- FVM for 2-D unsteady state diffusion problems.

Solution of linear algebraic equation- Basic numerical methods, Direct method, Tri-diagonal Matrix algorithm, TDMA and other iterative methods.

C. Text Books:

1. Chung, T. J., "Computational Fluid Dynamics", 2nd Ed., 2014, Cambridge University Press.

2. Anderson J. D. (Jr)., "Computational Fluid Dynamics: The basic with applications", 2017, McGraw Hill Education.

D. Reference Books:

1. Patankar, S. V., "Numerical Heat Transfer and Fluid Flow", 2017, CRC Press.

2. Versteeg, H. K., Malalasekera, W., "An Introduction to Computational Fluid Dynamics", 2nd Ed., 2007, PHI.

3. Ferziger, J. H. and Peric, M., "Computational Methods for Fluid Dynamics", 3rd Ed., 2002, Springer.

E. Course Outcomes:

Upon completion of this course, the students will be able to:

1. Understand the basic concepts and its solution for aerodynamic flow.
2. Define and setup flow problems within CFD context.
3. Solve Navier-Stokes equations with proper initial and boundary conditions.
4. Use CFD software to model relevant engineering flow problems and analyse the results.

Name of the Module: Advanced Solid Mechanics
Module Code: 403A
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To make students understand the principles of elasticity.
2. To familiarize students with basic equations of elasticity.
3. To expose students to two and three dimensional problems in Cartesian and polar coordinates.
4. To make students understand the strain-energy methods.
5. To introduce to students the method of calculation of stresses in components of circular and noncircular cross section subjected to unsymmetrical bending and torsional loading.

B. Course Content:

Analysis of stress and strain: Three dimensional stresses in arbitrary plane, Principal Stresses, Stress Invariants, Mohr's Circle for 3-D state of stress, Octahedral Stresses, State of pure shear, Differential equations of equilibrium and compatibility conditions, plane stress. Analysis of strain, State of strain at a point, Strain Invariant, Principal Strains, Plane state of strain.

Energy Methods: Strain Energy, Strain-Energy Density, Elastic Strain Energy for Normal Stresses, Elastic Strain Energy for Shearing Stresses, Strain Energy for a General State of Stress, Castigliano's Theorem, Deflections by Castigliano's Theorem, Statically Indeterminate Structures.

Bending of Beams: Bending of symmetric and unsymmetrical straight beams, effect of shear stresses, Curved beams, Shear center and shear flow, shear stresses in thin walled sections, thick curved bars. Stresses in thick and thin walled cylinders, Composite tubes, Rotating disks and cylinders.

Theory of Columns and Introduction to elasticity: Euler's buckling load, Beam Column equations. Strain measurement techniques using strain gages, characteristics, instrumentations, principles of photo-elasticity.

C. Text Books:

1. Srinath, L.S., "Advanced Mechanics of Solids", 3rd Ed., 2010, McGraw Hill Education.
2. Boresi, A.P. and Schmdt, R.J., "Advanced Mechanics of Materials", 6th Ed., 2009, Willey Publication.
3. Beer, F.P. and Johnston, E.R., "Mechanics of Materials", 6th Ed., 2017, McGraw Hill.

D. Reference Books:

1. *Timoshenko, S., "Strength of Materials Vol. II: Advanced Theory and Problems" 3rd Ed, 2012, CBS Publishers.*

2. *Ryder, G. H., "Strength of Materials",3rd Ed. 1961, Palgrave Macmillan Press.*
3. *Budynas, R. G., "Advanced Strength and Applied Stress Analysis" 2nd Ed.1998, McGraw-Hill Education.*

E. Course Outcomes: Upon completion of the subject, students should have the knowledge of:
1. Understand 3D stress and strain components.
2. Utilize energy methods for solving the problems of theory of elasticity.
3. Solve the unsymmetrical straight and curved beam problem.
4. Examine the thick and thin walled cylinder problems.
5. Model the structural column problems.

Name of the Module: Mechanical Vibration
Module Code: 403B
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:
1. Introduction to mathematical models of problems in free and forced vibrations using Newton's second law or energy principles.
2. Determine a complete solution to the modelled mechanical vibration problems.
3. Correlate results from the mathematical model to physical characteristics of the actual system.
4. Design of a mechanical system using fundamental principles of vibration.

B. Course Content:
Introduction: Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, Physical models, Schematic models and Mathematical models.

Free Vibration Analysis: Formulation of equation of motion: D-Alembert's method, Energy method, Newton's method and Rayleigh methods. Differential equations of motion for first order and second order linear systems. Un-damped Free vibration response, Damped Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition Problem formulation and response calculation.

Forced Vibration analysis: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Problems on forced vibration.

Two degree of freedom systems: Introduction, Formulation of equation of motion, Equilibrium method, Lagrangian method, Problem formulation of equations of motion.

Multi degree of freedom systems: Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.

Vibration Analysis of Continuous systems: Introduction to continuous systems, Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems and Approximate methods for continuous systems.

C. Text Books:

1. *Meirovich, L., "Elements of Vibration Analysis", 2nd Ed., 2014, McGraw-Hill.*
2. *Rao, S.S, "Mechanical Vibrations", 6th Ed., 2018, Pearson Education.*
3. *Thomson, W.T., "Theory of Vibration with applications", 5th Ed., 2002, Pearson Education.*

D. Reference Books:

1. *Clarence W. de Silva, "Vibration: Fundamentals and Practice", 2nd Ed., 2006, CRC Press.*

E. Course Outcomes: Upon completion of the subject, students should have the knowledge of:

1. Construct the governing differential equation and able to solve for the motion and the natural frequency of damped and un-damped system.
2. Formulate any periodic function in terms of a series of simple harmonic motions using Fourier series analysis.
3. Solve for the motion and the natural frequency for forced vibration of a single degree of freedom damped or un-damped system.
4. Obtain the complete solution for the motion of a single degree of freedom vibratory system (damped or un-damped) that is subjected to non-periodic forcing functions.
5. Acquire design parameters and indicate methods of solution for a complicated vibratory problem.

Name of the Module: Advanced Machining Processes
Module Code: 403C
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To develop the relations for shear angle, forces, power consumption in orthogonal cutting/ machining processes.
2. Selection of cutting tools, cutting tool materials and tool geometry for improved machinability and tool life.
3. To understand the laser processing of materials.
4. To understand, design and analyse methods and tools used for micro and nano fabrication.

B. Course Content:

Introduction: Introduction to modelling of manufacturing processes, need and development of processes, applications.

Metal cutting: Force analysis, shear angle, Merchant circle problems in metal cutting, temperature distribution in metal cutting; measurement of temperature in metal cutting; cutting tool geometry and cutting tool materials; economics in metal cutting, machinability studies of ductile and brittle materials; advanced machining processes like hard turning and high speed machining.

Laser machining: Introduction to laser machining, application and advantages, laser drilling, effect of process parameters on machinability characteristics of materials, laser cutting, quality aspects in laser machining, applications of laser micromachining.

Microfabrication techniques: Lithography, Thin film deposition and doping, etching and substrate removal, substrate bonding, MEMS fabrication techniques, bulk micromachining, surface micromachining, high aspect ratio micromachining.

Nanofabrication techniques: E-beam and nano-imprint fabrication, epitaxy and strain engineering, scanned probe techniques, self-assembly and template manufacturing.

C. Text Books:

1. Shaw, M. C., Metal Cutting Principles, 2nd Ed., 2004, Oxford University Press.
2. Wang, L. and Xi, J., Smart Devices and Machines for Advanced Manufacuring, 2008, Springer.
3. Dahotre, N. B. and Harimkar, S. P., Laser Fabrication and Machining of Materials, 2014, Springer.
4. Mark, J. J., Microfabrication and Nanomanufacturing, 1st Ed., 2005, CRC Press.

D. Reference Books:

1. Kalpakjian, S. and Schmid, S. R., Manufacturing Processes for Engineering Materials, 6th Ed., 2018, Pearson education.
2. Homyak, G. L., Dutta, J., Tibbals, H. F., and Moore, J. J., Introduction of Nanoscience and Nanotechnology, 2019, CRC Press.
3. Mishra, P. K., Non-conventional Machining, 1997, Narosa Publishing House.

E. Course Outcomes: Upon completion of this course, the students will be able to:

1. Understand the relationship between shear angle, forces, and power consumption in orthogonal cutting / machining processes.
2. Understand the laser processing of materials and its applications in industries.
3. Analyse methods and tools used for micro and nano fabrication.
4. Identify industrially viable processes, equipment and manufacturing tools for specific industrial products.

Name of the Module: Robotics
Module Code: 403D
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To explain the basic principles of Robotic technology, configurations, control and applications of robots.
2. To explain the basic concept Coordinate Frames, Mapping and Transforms.
3. To describe the concept of Robot kinematics and dynamics.
4. To choose the appropriate Sensor and vision system for a robot for a given application.
5. To understand the motion planning and control trajectory of the robot.

B. Course Content:

Introduction: Basic concepts, definition and origin of robotics, different types of robots, robot classification, applications, robot specifications.

Coordinate Frames, Mapping and Transforms: Coordinate Frames, Description of Objects in Space, Transformation of Vectors, Inverting a Homogeneous Transform, Fundamental Rotation Matrices. Mechanical Structure and Notations, Description of Links and Joints, Kinematic Modeling of the Manipulator, Denavit-Hartenberg Notation, Kinematic Relationship between Adjacent Links, Manipulator Transformation matrix.

Kinematic Modeling of Robots: Position analysis – Direct and Inverse Kinematic Models of Robotic Manipulators, Various examples. Velocity Analysis–Jacobian matrix.

Dynamics of Robots Modeling of Robots: Dynamic analysis of the manipulator robot, Newton-Euler formulation, Lagrange-Euler dynamic formulation, static force analysis, transformation of force and moment.

Robotic Sensors and Vision: Sensors in Robotics, Architecture of Robotic Vision Systems, Image Acquisition, Components of Vision, System, Image Representation, Image Processing.

Motion Planning and Control: Basics of trajectory planning, Cartesian space trajectory, basics of control, block diagram, Laplace transform, PID control, trajectory planning - position, velocity and force control.

C. Text Books:

1. Craig,J.J,, "Introduction to Robotics: Mechanics and Control",3rd Ed., 2008, Pearson Education International.
2. Spong, M.W., and Vidyasagar. M., "Robot Dynamics and Control", 2008, Wiley.
3. Schilling,R.J, "Fundamentals of Robotics Analysis and Control", 1990, Prentice Hall of India.

D. Reference Books:

1. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., "Robotics control, Sensing, Vision and Intelligence", 1987, McGraw-Hill.
2. Saha, S.K., "Introduction to Robotics", 2nd Ed., 2014, McGraw Hill.

E. Course Outcomes: Upon completion of this course, the students will be able to:

1. Have basic knowledge on various components of robotic system.
2. Develop suitable model for forward and inverse kinematics of robot manipulators.
3. Analyse forces in links and joints of a robot.
4. Model for trajectory planning and control mechanism of robot.

Name of the Module: Principles of Product Design
Module Code: 403E
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To study the basic concepts of product design and development process.
2. To expose the students to different design principles like designing for function, production, maintenance, packaging etc.

3. To study the applicability of product design and development in industrial applications including product specifications, concept development, design for prototyping and manufacturing.

B. Course Content:

Introduction: Product design definition and evolution, product design morphology, product life cycle, product policy of an organization, selection of a profitable product, product design process, product analysis.

Product design: Flow charting, creativity techniques, translating customer needs, product development process.

Value engineering in product design: Advantages, applications in product design, problem identification and selection, functional analysis, functional analysis system techniques (FAST), case studies.

Product design tools: Quality function development (QFD), computer aided design, robust design, design for excellence, design for manufacturing, design for assembly, ergonomics in product design.

Product costing: Elements of product cost, life cycle costing, material selection, metals and alloys, plastics, ceramics, rubber.

Design for manufacturing and assembly: Guidelines, product design for manual assembly, design guidelines for metallic and non-metallic products to be manufactured by different processes such as casting, machining, injection molding etc., rapid prototyping, needs, advantages, working principle of stereo lithography, laminated object manufacturing, selective laser sintering.

C. Text Books:

1. *Eppinger, S. and Ulrich, K., 'Product design and development', 5th Ed., 2011, McGraw Hill Higher Education.*
2. *Magrab, E. B., Gupta, S. K., McCluskey, F. P. and Sandborn, P., 'Integrated product and process design and development: The product realization process', 2nd Ed., 2019, CRC Press.*
3. *Ulrich, K. T., Eppinger, S. D., 'Product Design & Development', 5th Ed., 2011, Tata McGraw Hill, New Delhi.*

D. Reference Books:

1. *Boothroyd, G., 'Product design for manufacturing and assembly: Computer Aided Design', 26 (7), 1994, pp 505-520.*
2. *Hollins, B. and Pugh, S., 'Successful Product Design', Butter Worths, London.*
3. *Bralla, J. G., 'Handbook of Product Design for Manufacture', 1986, McGraw Hill, New York.*

E. Course Outcomes: Upon completion of this course, the students will be able to:

1. Describe an engineering design and development process.
2. Employ engineering, scientific and mathematical principles to execute a design from concept to finished product.
3. Choose an appropriate standardization method for product and develop methods to minimize the cost.
4. Explain product design for manufacturing and manual assembly.

Name of the Module: Experimental Methods
Module Code: 403F
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is design to meet with the following objectives:
1. To learn basic concept of experimental methods.
2. To learn techniques involve in measurement and its principles.
3. To familiar with different measuring instruments related to fluid flow and heat transfer.
4. To learn methods of measurement of physical quantities and uncertainty analysis.

B. Course Content:
Introduction- Importance of measurement and experimentation, Basic issues in measurements, Signal flow diagram of measurement system.

Principles of measurement- Causes and types of errors in measurement, Error analysis and method for error estimate, Propagation of errors, Regression analysis, Calibration, Curve fitting and quality of curve fitting, zero order, first order, second order systems, Inputs and their methods of correction - broad category of methods for measuring field and derived quantities, Design of experiments, control systems, PID, LVDT, data acquisition.

Pressure measurement- Manometers, Electric pressure transducers, Bourdon tube pressure gage, Diaphragm gage.

Flow rate measurement- Positive displacement flow meters, venture, orifice, impact tube, flow nozzle, sonic nozzle, rotameter, pitot static tube, hot-wire anemometer, laser Doppler anemometer, flow visualization techniques – shadowgraph, Schlieren and interferometer.

Thermometry- Hg-in-glass thermometer, RTD, thermocouple, optical pyrometer, Effect of heat transfer on temperature measurement, errors of system/sensor interaction.

Thermal conductivity measurement- Guarded hot plate apparatus, heat flux meter.

Uncertainty analysis.

C. Text Books:
1. *Holman, J. P., "Experimental Methods for Engineers", 7th Ed., 2017, McGraw Hill Education.*
2. *Beckwith, T.G., Lienhard, J. H. and Marngoni, V. R. D., "Mechanical Measurements", 6th Ed., 2013, Pearson Education.*

D. Reference Books:
1. *Dally, J. W., Riley, W. F. and McConnel, K. G., "Instrumentation for Engineering Measurements", 2nd Ed., 1993, John Wiley & Sons.*
2. *Doebelin, E.O. "Measurement systems, Application and Design", 2nd Ed., 1990, Tata McGraw-Hill.*

E. Course Outcomes:
Upon completion of the subject, students will be able to:
1. Understand the basics of errors in measurement and its importance.

2. Describe mathematical and experimental techniques involved in measurement of different physical quantities.
3. Analyse calibration of measuring instruments.
4. Evaluate uncertainty in measured and derived quantities.

Name of the Module: Principles of Tribology
Module Code: 403G
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives: The course is designed to meet with the following objectives:

1. To provide the students with the fundamental concepts and principles of tribology.
2. Emphasis on the design, selection and performance of lubricated components such as pistons, bearings, gears etc.
3. To understand the concepts of friction and wear and to deal with surface properties, contact mechanics in the field of Industrial Tribology.

B. Course Content:

Introduction: Introduction to tribology, history of tribology, interdisciplinary approach, economic benefits.

Friction: Causes of friction, adhesion theory, abrasive theory, junction growth theory, laws of rolling friction, friction instability.

Wear: Wear mechanisms, adhesive wear, abrasive wear, corrosive wear, fretting wear, wear analysis.

Lubrication and lubricants: Importance of lubrication, boundary lubrication, mixed lubrication, full fluid film lubrication, types and properties of lubricants, lubricants additives.

Fluid film lubrication: Concept of fluid mechanics, equation of continuity and motion, generalized Reynolds equation with compressible and incompressible lubricants.

Application of tribology: Rolling contact bearings, gears, journal bearings, finite bearings.

C. Text Books:

1. Halling, J., Principles of Tribology, 1978, The Macmillan Press Ltd., London.
2. Dowson, D., History of Tribology, 1979, Longman London.
3. Ludema, K. C., Friction, Wear, Lubrication: A textbook in Tribology, 2018, CRC Press.
4. Majumdar, B. C., Introduction to Tribology of Bearings, 2010, S Chand & Company.
5. Cameron, A. and Mc Ettles, C. M., Basic Lubrication Theory, 1987, Wiley Eastern Ltd., New Delhi.

D. Reference Books:

1. *Stachowiak, G. N., Batchelor, A. W. and Stachowick, G. B., Experimental methods in Tribology, Tribology series 44, Editor D. Dowson, 2004.*
2. *Khonsari, M. M., Applied Tribology (Bearing Design and Lubrication), 3rd Ed., 2017, John Wiley & Sons.*
3. *Edwards, K. S. and McKee, R. B., Fundamentals of Mechanical Component Design, 1991, McGraw Hill Inc.*

E. Course Outcomes: Upon completion of this course, the students will be able to:

1. Understand basic principles of tribology.
2. Apply the theories of friction, wear and lubrication to predict frictional behaviour of commonly encountered sliding interfaces.
3. Differentiate the features of rough surface and liquid lubricants.
4. Anticipate the latest research on new topics in tribology including its application to nanoscale devices and biological systems.

Name of the Module: Advanced Thermodynamics
Module Code: 403H
Credit Value: 3 [L = 3, T = 0, P = 0]

A. Course Objectives:

This subject designed to meet the following objectives:

1. To learn about thermodynamic relations, exergy, non-reactive gas mixtures in advanced level.
2. To understand the practical applications of the concepts of thermodynamics.
3. To deal with advanced thermodynamic problems in the practical fields.

B. Course Content:

Thermodynamic relations- Generalized relation for C_p, C_v, K, relations for internal energy and enthalpy, the various Tds equation, clapeyron equation, Helmhotz free energy function, Gibbs free energy function, coefficient of volumetric expansion, isothermal compressibility, differential relation for U, H, G and F-Maxwell relations.

Exergy- Introduction, definition, exergy of closed and open system, exergetic efficiency, exergy analysis of systems and components, entropy generation minimization, finite time thermodynamics, thermo economics.

Non-reactive gas mixtures- introduction, basic definitions for gas mixtures, p-v-t relationship for mixtures of ideal gases, properties of mixtures of ideal gases, entropy change due to mixing, mixtures of perfect gases at different initial pressure and temperatures.

Direct energy conversion- Introduction, thermoelectric converters, thermo-ionic converters, magneto hydrodynamics generators, solar power cells plant, fuel cell hydrogen, hydrogen fuel cells, direct and indirect oxidation fuel cells, biochemical fuel cells.

Statistical thermodynamics- Introduction to statistical thermodynamics

C. Text Books:

1. *Wylen, G. V. and Sontag, R. E., "Fundamentals of Classical Thermodynamics", 4th Ed., 1994,Wiley Eastern Limited, New Delhi.*
2. *Moran, M. J. and Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 8th Ed., 2014, John Wiley and Sons.*
3. *Sears, F. W. and Salinger, G. L., "Thermodynamics, Kinetic Theory and Statistical Thermodynamics", 1998, Narosa Publishing House, New Delhi.*

D. Course Outcomes:

After studying this course, students will be able to

1. Understand the basic principles of advanced thermodynamics.
2. Apply the exergy concepts in entropy generation.
3. Create pressure, volume and temperature relationships for mixtures of ideal and perfect gases.
4. Identify the latest direct energy conversion systems and also know about statistical thermodynamics.

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