III SEMESTER											
Sl. No	**Course (Subject) code**	**Course (Subject)**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Tutorial**	**Practical /Drawing**	**Duration in hours**	**CIE Marks**	**SEE Theory/ Practical Marks**	**Total Marks**	
1	18MAT31	BS	Mathematics III	2	2	--	03	40	60	100	3
2	18ME32	PC	Mechanics of Materials	3	2	--	03	40	60	100	4
3	18ME33	PC	Basic Thermodynamics	3	0	--	03	40	60	100	3
4	18ME34	PC	Material Science	3	-	--	03	40	60	100	3
5	18ME35 A	PC	Metal Casting and welding	3	-	--	03	40	60	100	3
	18ME35 B		Metal cutting and forming								
6	18ME36A	PC	Computer aided Machine drawing	1	-	04	03	40	60	100	3
	18ME36B		Mechanical Measurements and Metrology	3	-	--					
7	18MEL37 A	PC	Material Testing lab	-	2	2	03	40	60	100	2
	18MEL37 B		Mechanical Measurements and Metrology lab								
8	18MEL38 A	PC	Workshop and Machine Shop Practice (Consists of fitting, welding and Machining)	-	2	2	03	40	60	100	2
	18MEL38 B		Foundryand forging lab								
9	18KAN39A	HSMC	Vyavaharika Kannada (Kannada for communication)/ Aadalitha Kannada (Kannada for Administration)	-	2	-	02	40	60	100	1
	18CPH39B		Constitution of India, Professional Ethics and Cyber Law	1	-	-					
TOTAL				16/18	10/ 08	08/ 04	26	420/ 360	540	900	24

IV SEMESTER												
Sl. No	**Course (Subject) code**	**Course Subject)**	**Course Title**	**Teaching Hours /Week**			**Examination**					
				Theory	**Tutorial**	**Practical/ Drawing**	**Duration in hours**	**CIE Marks**	**SEE Theory/ Practical Marks**	**Total Marks**	**Credits**
1	18MAT41	BS	Mathematics IV	2	2	--	03	40	60	100	3
2	18ME42	PC	Applied Thermodynamics	3	2	--	03	40	60	100	4
3	18ME43	PC	Fluid Mechanics	3	0	--	03	40	60	100	3
4	18ME44	PC	Kinematics of Machines	3	0	--	03	40	60	100	3
5	18ME45 A	PC	Metal Casting and welding	3	0	--	03	40	60	100	3
	18ME45 B		Metal cutting and forming								
6	18ME46A	PC	Computer aided Machine drawing	1	0	4	03	40	60	100	3
	18ME46B		Mechanical Measurements and Metrology	3	0	0					
7	18MEL47 A	PC	Material Testing lab	--	2	2	03	40	60	100	2
	18MEL47 B		Mechanical Measurements and Metrology lab								
8	18MEL48 A	PC	Workshop and Machine Shop Practice (Consists of fitting, welding and Machining)	--	2	2	03	40	60	100	2
	18MEL48 B		Foundry and forging lab								
9	18KAN49A	HSMC	Vyavaharika Kannada (Kannada for communication)/Aadalitha Kannada (Kannada for Administration)		2	--	-	100	-	100	1
	18CPH49B		Constitution of India, Professional Ethics and Cyber Law	1	-	-	03	40	60	100	
TOTAL				17/ 20	08/ 10	08/ 04	24/ 27	420/ 360	540/ 480	900	24

V SEMESTER											
Sl No	**Course (Subject) code**	**Course (Subject)**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Tutorial**	**Practical/ Drawing**	**Duration in hours**	**CIE Marks**	**SEE Theory/ Practical Marks**	**Total Marks**	
1	18XX51	HSMC	Management and Economics	2	2	--	03	40	60	100	3
2	18ME52	PC	Design of Machine Elements-I	3	2	--	03	40	60	100	4
3	18ME53	PC	Dynamics of Machines	3	2	--	03	40	60	100	4
4	18ME54	PC	Turbomachines	3	-	--	03	40	60	100	3
5	18ME55	PC	Fluid Power Engineering	3	-	--	03	40	60	100	3
6	18ME56	PC	Heat Transfer	3	-	0	03	40	60	100	3
7	18MEL57	PC	Fluid mechanics/machines lab	--	2	2	03	40	60	100	2
8	18MEL58	PC	Energy Conversion Lab	--	2	2	03	40	60	100	2
9	18CIV59	HSMC	Environmental Studies	1	--	--	02	40	60	100	1
TOTAL				**19**	**06**	**04**	**24**	**320**	**480**	**900**	**25**

VI SEMESTER											
Sl. No	**Course (Subject) code**	**Course (Subject)**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Tutorial**	**Practical/ Drawing**	**Duration in hours**	**CIE Marks**	**SEE Theory/ Practical Marks**	**Total Marks**	
1	18ME61	PC	Finite element methods	3	2	--	03	40	60	100	4
2	18ME62	PC	Design of Machine Elements-II	3	2	--	03	40	60	100	4
3	18ME63	PC	Control Engineering	3	2	--	03	40	60	100	4
4	18ME64X	PC	Elective -1	3	-	--	03	40	60	100	3
5	18ME65X	OE	Open Elective – A	3	-	--	03	40	60	100	3
6	18MEL66	PC	Computer aided Modeling and analysis Lab	--	2	2	03	40	60	100	2
7	18MEL67	PC	Heat Transfer Lab	--	2	2	03	40	60	100	2
8	18MEMP68	MP	Mini-project (Completed during the intervening vacations of V and VI semesters)	--	-	-	03	40	60	100	2
9	Internship	INT	Internship (To be carried out during the intervening vacations of VI and VII semesters)	--	-	2	-	-	-	-	-
TOTAL				**15**	**10**	**06**	**24**	**320**	**480**	**800**	**24**

The open elective courses on offer will be subject to availability of time table slot, faculty members, class rooms and minimum class strength specified from time to time.

VII SEMESTER											
Sl. No	**Course (Subject) code**	**Course (Subject)**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Tutorial**	**Practical/ Drawing**	**Duration in hours**	**CIE Marks**	**SEE Theory/ Practical Marks**	**Total Marks**	
1	18ME71	PC	Operations Management	3	-	--	03	40	60	100	3
2	18ME72	PC	Computer Integrated Design &Manufacturing	3	-	--	03	40	60	100	3
3	18ME73X	PE	Elective-2	3	-	--	03	40	60	100	3
4	18ME74X	PE	Elective-3	3	-	--	03	40	60	100	3
5	18ME75X	OE	Open Elective B	3	-	--	03	40	60	100	3
6	18MEL76	PC	Computer Integrated Manufacturing Lab	-	2	2	03	40	60	100	2
7	18MEL77	PC	Design Lab	-	2	2	03	40	60	100	2
8	18MEP78	Project	Project Work Phase - 1	-	-	2	-	100	-	100	1
8	Internship	INT	Internship (If not completed after VI semester examinations, it has to be carried out during the intervening vacations of VII and VIII semesters)	-	-	-	-	-	-	-	-
			TOTAL	**17**	**--**	**04**	**18**	**340**	**360**	**700**	**20**

VIII SEMESTER											
Sl. No	**Course (Subject) code**	**Course (Subject)**	**Course Title**	**Teaching Hours /Week**			**Examination**				**Credits**
				Theory	**Tutorial**	**Practical/ Drawing**	**Duration in hours**	**CIE Marks**	**SEE Theory/ Practical Marks**	**Total Marks**	
1	18ME81	PC	Energy Engineering	3	-	--	03	40	60	100	3
2	18ME82X	PE	Elective-4	3	-	--	03	40	60	100	3
3	18MEP83	Project	Project Work Phase - 2	-	-	02	03	40	60	100	8
4	18MES84	Seminar	Technical Seminar	-	-	02	03	100	-	100	1
5	18MEI85	INT	Internship (Completed during the intervening vacations of VI and VII semesters and /or VII and VIII semesters.)	-	-	-	03	40	60	100	3
			TOTAL	**06**	**-**	**04**	**15**	**260**	**240**	**500**	**18**

List of Professional Electives proposed:

Elective-1

Course Code	Course Title	Credits
18ME641	Non-Traditional Machining	3
18ME642	Refrigeration and Air conditioning	3
18ME643	Operations Research	3
18ME644	Financial Management	3
18ME645	Composite Materials Technology	3

Open Elective A

Note:

Students can select any one of the open electives offered by other Departments except those that are offered by the parent Department.

Course Code	Course Title	Credits
18ME651	Financial Management	3
18ME652	Project Management	3
18ME653	Six Sigma	3
18ME654	Automotive Engineering	3

Elective-2

Course Code	Course Title	Credits
18ME731	Design for manufacture	3
18ME732	Automation and Robotics	3
18ME733	Computational Fluid Dynamics	3
18ME734	Total Quality Management	3
18ME735	Cryogenics	3

Open Elective B

Course Code	Course Title	Credits
18ME751	Energy Auditing	3
18ME752	Supply Chain Management	3
18ME753	Total Quality Management	3
18ME754	Optimization Techniques	3

Elective-3

Course Code	Course Title	Credits
18ME741	Additive Manufacturing	3
18ME742	Design of Experiments	3
18ME743	Non-Destructive Testing and Evaluation	3
18ME744	Energy and Environment	3
18ME745	Tribology	3

Elective-4

Course Code	Course Title	Credits
18ME821	CNC Machine tools	3
18ME822	Mechatronics	3
18ME823	Energy Auditing	3
18ME824	Automobile engineering	3
18ME825	Project Management	3

Sl. No	Semester	Credits
1	I	20
2	II	20
3	III	24
4	IV	24
5	V	25
6	VI	24
7	VII	20
8	VIII	18
Total		175

III SEMESTER MECHANICAL 2018 SCHEME

Mechanics of Materials

III Semester

Subject Code	**18ME32**	**CIE Marks**	**40**
Number of Hours/Week	**3L+2T**	**SEE Marks**	**60**
Total Number of Hours	**70 (50L+20T)**	**Exam. Hours**	**03**
Number of Credits: 4			

Content	Hours/ RBT Level
Module 1 **Stresses and Strains:** Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.	**10 Hours** **L1, L2, L3**
Module 2 **Analysis of Stress and Strain:** Plane stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear tress, Mohr circle for plane stress conditions. **Cylinders:** Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations.	**10 Hours** **L1, L2, L3, L4**
Module 3 **Shear Force and Bending Moment:** Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads, uniformly distributed constant / varying loads.	**10 Hours** **L1, L2, L3, L4**

Stress in Beams: Bending and shear stress distribution in rectangular, I and T section beams.	
Module 4 **Theories of Failure:** Maximum Principal stress theory, Maximum shear stress theory for 2D cases. Torsion: Circular solid and hallow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections, Thin tubular sections, Thin walled sections.	**10 Hours** **L1, L2, L3, L4**
Module 5 **Columns**: Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns, Secant formula for columns. **Strain Energy:** Strain energy due to axial , shear, bending, torsion and impact load. Castigliano's theorem I and II and their applications.	**10 Hours** **L1, L2, L3, L4**

Course Outcomes:

After studying this course, students will be able to:

CO1	Understand simple, compound, thermal stresses and strains their relations and strain energy.
CO2	Analyse structural members for stresses, strains and deformations.
CO3	Analyse the structural members subjected to bending and shear loads.
CO4	Analyse shafts subjected to twisting loads.
CO5	Analyse the short columns for stability.

Text Books:

1. J M Gere, B J Goodno, Mechanics of Materials, Eighth Edition, Cengage, 2013.
2. Fundamentals of Strength of Materials – P N Chandramouli; PHI Learning Pvt. Ltd., 2013
3. Strength of Materials – R K Rajput; S. Chand and Company Pvt. Ltd. 2014

Reference Books:

1. R. Subramanian, Strength of Materials, Oxford, 2005.
2. S. S. Ratan, Strength of Materials, 2nd Edition, Tata McGraw Hill, 2008.
3. S C Pilli and N Balasubramanya Mechanics of materials: Strength of Materials, Cengage, 2019.
4. Mechanics of Materials – Ferdinand Beer, Russell Johston, John Dewolf, David Mazurek; McGraw Hill Education (India) Pvt. Ltd., Latest edition
5. Mechanics of Materials – R C Hibbeler; Pearson, Latest edition

BASIC THERMODYNAMICS

III Semester

Subject Code	**18ME33**	**CIE Marks**	**40**
Number of Hours/Week	**03 L**	**SEE Marks**	**60**
Total Number of Lecture Hours	**40**	**Exam Hours**	**03**
No. of Credits: 3			

Course Objectives:

CLO1	Learn about thermodynamic system and its equilibrium
CLO2	Understand various forms of energy - heat transfer and work
CLO3	Study the basic laws of thermodynamics including, zeroth law, first law and second law.
CLO4	Interpret the behavior of pure substances and its application in practical problems.
CL05	Study of Ideal and real gases and evaluation of thermodynamic properties

Content	**No. of Hours/RBT levels**
Module - 1	**8 Hours**
Fundamental Concepts & Definitions: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive , extensive properties, specific properties, pressure, specific volume Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics, Temperature; concepts,	**L1, L2, L3**

scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gas thermometer, mercury in glass thermometer.	
Module 2 **Work and Heat**: Mechanics, definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Problems. **First Law of Thermodynamics:** Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, Extension of the First law to control volume; steady flow energy equation(SFEE), important applications.	**8 Hours** **L1, L2, L3,L4**
Module 3 **Second Law of Thermodynamics:** Limitations of first law of thermodynamics, Thermal reservoir, heat engine and heat pump: Schematic representation, efficiency and COP. Reversed heat engine, schematic representation, importance and superiority of a reversible heat engine and irreversible processes, internal and external reversibility. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles. Problems **Entropy:** Clausius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate.	**8 Hours** **L1, L2, L3, L4**
Module 4 **Availability, Irreversibility and General Thermodynamic relations.** Introduction**,** Availability (Exergy), Unavailable energy, Relation between increase in unavailable energy and increase in entropy. Maximum work, maximum useful work for a system and control volume, irreversibility. **Pure Substances:** P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes	**8 Hours** **L1, L2, L3**

on these diagrams. Steam tables and its use. Throttling calorimeter, separating and throttling calorimeter.	
Module- 5 **Ideal gases:** Ideal gas mixtures, Daltons law of partial pressures, Amagat's law of additive volumes, evaluation of properties of perfect and ideal gases, Air- Water mixtures and related properties. **Real gases –** Introduction , Van-der Waal's Equation of state, Van-der Waal's constants in terms of critical properties, Beattie-Bridgeman equation , Law of corresponding states, compressibility factor; compressibility chart. Difference between Ideal and real gases.	**8 Hours** **L1, L2, L3**

Corse Outcomes:
After studying this course, students will be able to:

CO1	Explain fundamentals of thermodynamics and evaluate energy interactions across the boundary of thermodynamic systems.
CO2	Evaluate the feasibility of cyclic and non-cyclic processes using 2nd law of thermodynamics.
CO3	Apply the knowledge of entropy, reversibility and irreversibility to solve numerical problems and apply 1st law of thermodynamics to closed and open systems and determine quantity of energy transfers and change in properties.
CO4	Interpret the behavior of pure substances and its application in practical problems.
CO5	Recognize differences between ideal and real gases and evaluate thermodynamic properties of ideal and real gas mixtures using various relations.

TEXT BOOKS:

1. Basic and Applied Thermodynamics, P.K.Nag, 2nd Ed., Tata McGraw Hill Pub. 2002
2. Basic Engineering Thermodynamics, A.Venkatesh, Universities Press, 2008
3. B.K Venkanna, Swati B. Wadavadagi "Basic Thermodynamics, PHI, New Delhi, 2010

REFERENCE BOOKS:

1. Thermodynamics, An Engineering Approach, Yunus A.Cenegal and Michael A.Boles, Tata McGraw Hill publications, 2002
2. Engineering Thermodynamics, J.B.Jones and G.A.Hawkins, John Wiley and Sons..
3. Fundamentals of Classical Thermodynamics, G.J.Van Wylen and R.E.Sonntag, Wiley Eastern.
4. An Introduction to Thermodynamcis, Y.V.C.Rao, Wiley Eastern, 1993,

MATERIAL SCIENCE
SEMESTER – III

Subject Code	**18ME34**	**CIE Marks**	**40**
Hours/Week	**3L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits: 03			

COURSE OBJECTIVES:

CLO1	The foundation for understanding the structure and behavior of materials common in mechanical engineering.
CLO2	Topics to explore the mechanical properties of metals and their alloys, polymers, ceramics, smart materials and composites.
CLO3	To understand modifications of material properties by heat treatment processes.
CLO4	Selections of different materials for various applications are highlighted.
CL05	Impart knowledge of various failure modes of materials.

Content	**No. of Hours/RBT levels**
Basics, Mechanical Behavior, Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures, Crystal imperfections – point, line, surface and volume imperfections. Atomic Diffusion: Phenomenon, Fick's laws of diffusion (First and Second Law); Factors affecting diffusion. **Mechanical Behavior**: Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering stress and true strains, Linear and non- linear elastic behavior and properties, Mechanical properties in plastic range: Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness. Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals.	**8 Hours** **L1, L2, L3**

Module 2 **Failure of Materials** **Fracture:** Type I, Type II and Type III, **Fatigue:** Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, S-N diagram, fatigue testing. **Creep:** Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness, numerical on diffusion, strain and stress relaxation. **Alloys, Steels, Solidification:** Concept of formation of alloys: Types of alloys, solid solutions, factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, Intermediate phases,(The same type of process will study in Iron Carbon Phase Diagrams) Gibbs phase rule Effect of non- equilibrium cooling, Coring and Homogenization Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels. Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, Cast metal structures Solidification of Steels and Cast irons. Numerical on lever rule.	**8 Hours** **L1, L2, L3, L4**
Module 3 **Heat Treatment, Ferrous and Non-Ferrous Alloys:** Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT) curves, Annealing: Recovery, Recrystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Martempering, Austempering, Concept of hardenability, Factors affecting it hardenability. Surface hardening methods: carburizing, cyaniding, nitriding, flame hardening and induction hardening, Age hardening of aluminum-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron and steel.	**8 Hours** **L1, L2, L3, L4**
Module 4 **Composite Materials** Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs), Particulate-reinforced and fiber- reinforced composites, Fundamentals of production of composites, characterization of composites, constitutive relations of composites, determination of composite properties from component properties, hybrid	**8 Hours** **L1, L2, L3**

composites. Applications of composite materials. Numerical on determining properties of composites.	
Module 5 **Other Materials, Material Selection** **Ceramics:** Structure types and properties and applications of ceramics. Mechanical / Electrical behavior and processing of Ceramics. **Plastics:** Various types of polymers/plastics and their applications. Mechanical behaviors and processing of plastics, Failure of plastics. **Other materials:** Brief description of other materials such as optical and thermal materials. Smart materials – fiber optic materials, piezo-electrics, shape memory alloys– Nitinol, superelasticity. Biological applications of smart materials - materials used as implants in human Body, selection of materials, performance of materials in service. Residual life assessment–use of non-destructive testing, economics, environment and Sustainability.	**8 Hours** **L1, L2, L3, L4**

COURSE OUTCOMES:

The student shall be able to:

CO1	Understand the mechanical properties of metals and their alloys.
CO2	Analyze the various modes of failure and understand the microstructures of ferrous and non-ferrous materials.
CO3	Describe the processes of heat treatment of various alloys.
CO4	Acquire the Knowledge of composite materials and their production process as well as applications.
C05	Understand the properties and potentialities of various materials available and material selection procedures.

TEXT BOOKS:

1. Smith, Foundations of Materials Science and Engineering, 4th Edition, McGraw Hill, 2009.
2. William D. Callister, Material science and Engineering and Introduction, Wiley, 2006.
3. Shackleford., & M. K. Muralidhara, Materials Science, Pearson Publication – 2007.

REFERENCE BOOKS

1. V.Raghavan, Materials Science and Engineering, , PHI, 2002
2. Donald R. Askland and Pradeep.P. Phule, the Science and Engineering of Materials, Cengage Learning, 4lh Ed., 2003.
3. George Ellwood Dieter, Mechanical Metallurgy, McGraw-Hill.
4. ASM Handbooks, American Society of Metals.
5. H. VanVlack, Elements of Materials Science and Engineering, Addison- Wesley Edn., 1998
6. Alan Cottrell, An introduction to Metallurgy, University Press India Oriental Longman Pvt. Ltd., 1974.

Metal cutting and Forming

SEMESTER – III/IV

Subject Code	**18ME35A/45A**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits: 3			

Course objectives:

CLO1	To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
CLO2	To introduce students to different machine tools to produce components having different shapes and sizes.
CLO3	To develop the knowledge on mechanics of machining process and effect of various parameters on machining.
CLO4	To acquaint with the basic knowledge on fundamentals of metal forming processes
CL05	To study various metal forming processes.

Content	No. of Hours/RBT levels
Introduction to Metal cutting: Orthogonal and oblique cutting. Classification of cutting tools: single, and multipoint; tool signature for single point cutting tool. Mechanics of orthogonal cutting; chip formation, shear angle and its significance, Merchant circle diagram. Numerical problems. Cutting tool materials and applications. **Introduction to basic metal cutting machine tools:** Lathe- Parts of lathe machine, accessories of lathe machine, and various operations carried out on lathe. Kinematics of lathe. Turret & Capstan Lathe.	**8 Hours** **L1, L2, L3,L4**

Module 2 **Milling:** Various Milling operation, classification of milling machines, Vertical & Horizontal milling, up milling & down milling. Indexing: need of indexing, simple, compound & differential indexing. **Drilling:** Difference between drilling, boring & reaming, types of drilling machines. Boring operations & boring machines. **Shaping, Planing and Slotting machines**-machining operations and operating parameters. **Grinding:** Grinding operation, classification of grinding processes: cylindrical, surface & centerless grinding. Types of grinding wheels, speeds and feeds, Nomenclature of grinding wheels.	**8 Hours** **L1, L2, L3,**
Module 3 Introduction to tool wear, tool wear mechanisms, tool life equations, effect of process parameters on tool life, machinability. Cutting fluid-types and applications, surface finish, effect of machining parameters on surface finish. Economics of machining process, choice of cutting speed and feed, tool life for minimum cost and production time. Numerical problems.	**8 Hours** **L1, L2, L3, L4**
Module 4 **MECHANICAL WORKING OF METALS** Introduction to metal forming processes & classification of metal forming processes. Hot working & cold working of metals. Forging: Smith forging, drop forging & press forging. Forging Equipment, Defects in forging. Rolling: Rolling process, Angle of bite, Types of rolling mills, Variables of rolling process, Rolling defects. Drawing & Extrusion: Drawing of wires, rods & pipes, Variables of drawing process. Difference between drawing & extrusion. Various types of extrusion processes.	**8 Hours** **L1, L2, L3,**

Module 5	8 Hours
Sheet Metal Operations: Blanking, piercing, punching, drawing, draw ratio, drawing force, variables in drawing, Trimming, and Shearing. Problems on blanking and drawing dies. Bending —- types of bending dies, Bending force calculation, problems. Embossing and coining. Types of dies: Progressive, compound and combination dies.	**L1,L2, L3, L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Explain the construction & specification of various machine tools.
CO2	Discuss different cutting tool materials, tool nomenclature & surface finish.
CO3	Apply mechanics of machining process to evaluate machining time.
C04	Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.
C05	Understand the concepts of different metal forming processes.
C06	Apply the concepts of design of sheet metal dies to design different dies for simple sheet metal components.

TEXTBOOKS:

1. P.N.Rao- Manufacturing Technology, Vol I & II, Tata McGraw Hill Pub. Co. Ltd., New Delhi,1998.
2. Sharma, P.C., A textbook of Production Technology – Vol I and II, S. Chand & Company Ltd., New Delhi, 1996.
3. Manufacturing Science, Amithab Gosh & A.K.Malik, East-West press 2001.
4. Production Technology (Manufacturing process, technology and Automation), R.K Jain, Khanna Publishers-2004.

REFERENCES:

1. Schuler -Metal Forming Handbook - Springer Verlag Publication.
2. Hosford,WF and Caddell,R.M. - Metal Forming: Mechanics and Metallurgy ,Prentice Hall, Eaglewood Cliffs,1993
3. Chapman W. A. J., Workshop Technology Vol. I and II, Arnold Publisher, New Delhi, 1998.
4. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., Elements of Manufacturing Technology, Vol II, Media Publishers, Bombay, 1988.
5. Jain. R. K., Production Technology, Khanna Publishers, New Delhi, 1988.
6. Kalpakjian, Manufacturing Engineering and Technology, Addision Wesley Congmen Pvt. Ltd., Singapore, 2000
7. Production Technology-HMT

METAL CASTING AND WELDING
III/IV Semester

Course Code	18ME35B /45B	CIE Marks	40
Number of Lecture Hours/Week	3L	SEE Marks	60
Total Number Hours	40	Exam Hours	03
No. of Credits: 3			

Course Objectives:

CLO1	To provide adequate knowledge of quality test methods conducted on welded and cast components.
CLO2	To provide knowledge of various casting process in manufacturing.
CLO3	To provide in-depth knowledge on metallurgical aspects during solidification of metal and alloys.
CLO4	To provide detailed information about the moulding processes.
CL05	To impart knowledge of various joining process used in manufacturing.
CL06	To impart knowledge about behaviour of materials during welding, and the effect of process parameters in welding,

Content	Hours/ RBT Level
Module 1 **Introduction & basic materials used in foundry:** **Introduction:** Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy. **Introduction to casting process & steps involved:** **Patterns:** Definition, classification, materials used for pattern, various pattern allowances and their importance. **Sand moulding:** Types of base sand, requirement of base sand. Binder, Additives definition, need and types; preparation of sand moulds. Melding machines- Jolt type, squeeze type and Sand slinger. **Study of important moulding process:** Green sand, core sand, dry sand, sweep mould, CO_2 mould, shell mould, investment mould, plaster mould, cement bonded mould. **Cores:** Definition, need, types. Method of making cores, **Concept of gating** (top, bottom, parting line, horn gate) and risers (open, blind) Functions and types.	**8 Hours** **L1, L2, L3**

Module 2 **MELTING & METAL MOLD CASTING METHODS** **Melting furnaces:** Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace. **Casting using metal moulds:** Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes.	**8 Hours** **L1, L2, L3**
Module 3 **SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE** **Solidification**: Definition, nucleation, solidification variables. Directional solidification-need and methods. Degasification in liquid metals-sources of gas, degasification methods. **Fettling and cleaning of castings:** Basic steps involved. Sand Casting defects-causes, features and remedies. Advantages & limitations of casting process **Nonferrous foundry practice**: Aluminum castings - advantages, limitations, melting of Aluminum using lift-out type crucible furnace. Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations.	**8 Hours** **L1, L2, L3**
Module 4 **Welding process:** Definition, Principles, classification, application, advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW). **Special type of welding:** Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and Electron beam welding.	**8 Hours** **L1, L2, L3**
Module 5 **METALLURGICAL ASPECTS IN WELDING, SOLDERING, AND BRAZING** Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ), Parameters affecting HAZ. Effect of carbon content on structure and properties of steel, Shrinkage in welds& Residual stresses. Concept of electrodes, filler rod and fluxes. Welding defects- detection, causes & remedy.	**8 Hours** **L1, L2, L3**

Soldering, brazing, gas welding: Soldering, Brazing, Gas Welding: Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding, Gas cutting, powder cutting. **Inspection methods:** Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic. Radiography, eddy current, holography methods of inspection.	

Course outcomes:

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

CO1	Describe the casting process and prepare different types of cast products.
CO2	Acquire knowledge on Pattern, Core, Gating, Riser system and to use Jolt, Squeeze, Sand Slinger moulding machines.
CO3	Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces.
CO4	Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mold castings.
CO5	Understand the Solidification process and Casting of Non-Ferrous Metals.
C06	Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes etc. used in manufacturing.
C07	Describe methods for the quality assurance of components made of casting and joining process

TEXT BOOKS:

1. "Principles of metal casting", Rechard W. Heine, Carl R. Loper Jr., Philip C. Rosenthal, Tata McGraw Hill Education Private Limited Ed.1976.
2. "Manufacturing Process-I", Dr.K.Radhakrishna, Sapna Book House, 5th Revised Edition 2009.
3. "Manufacturing Technology": Foundry, Forming and Welding, P.N.Rao, 3rd Ed., Tata McGraw Hill, 2003.

REFERENCE BOOKS

1. "Process and Materials of Manufacturing", Roy A Lindberg, 4th Ed.Pearson Edu. 2006.
2. "Manufacturing Technology", Serope Kalpakjian, Steuen. R. Sechmid,Pearson Education Asia, 5th Ed. 2006.

E- Learning:

- VTU, E- learning

COMPUTER AIDED MACHINE DRAWING

SEMESTER III/IV

Subject Code	**18ME36A/18ME46A**	**CIE Marks**	**40**
No. of Hours/week	**1L+4P**	**SEE Marks**	**60**
Total Hours	**70**	**Exam Hours**	**03**
No. of credits: 3			

COURSE OBJECTIVES:

CLO1	To acquire the knowledge of CAD software and its features.
CLO2	To familiarize the students with Indian Standards on drawing practices.
CLO3	To impart knowledge of thread forms, fasteners, keys, joints and couplings.
CLO4	To make the students understand and interpret drawings of machine components leading to preparation of assembly drawings manually and using CAD packages.
CL05	To acquire the knowledge of limits, tolerance and fits and indicate them on machine drawings.

Content	**No. of Hours/RBT levels**
Part A **Introduction:** Review of graphic interface of the software. Review of basic sketching commands and navigational commands. Starting a new drawing sheet. Sheet sizes. Naming a drawing, Drawing units, grid and snap. Conversion of pictorial views into orthographic projections of simple machine parts (with and without section). Hidden line conventions. Precedence of lines.	**15 Hours** **L1, L2, L3, L4**

Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections. Conversion of pictorial views into orthographic projections of simple machine parts. Hidden line conventions. Precedence of lines. Conversion of pictorial views into orthographic projections of simple machine parts (with section planes indicated on the part). Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal & External) square and Acme. Sellers thread, American Standard thread. Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.	
Part B **Keys:** Parallel key, Taper key, Feather key, Gib-head key and Woodruff key. **Joints:** Cotter joint (socket and spigot), knuckle joint (pin joint) for two rods. **Couplings:** Split Muff coupling, Protected type flanged coupling, pin (bush) type flexible coupling, and universal coupling (Hooks' Joint)	**15 Hours** **L1, L2, L3, L4**
Part C Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in industry. **Assembly Drawings: (Part drawings shall be given)** **1. Plummer block (Pedestal Bearing)** **2. Lever Safety Valve** **3. I.C. Engine connecting rod** **4. Screw jack (Bottle type)** **5. Tailstock of lathe** **6. Machine vice** **7. Tool head of shaper**	**40 Hours** **L1, L2, L3, L4**

Outcomes:

After studying this course, students will be able to:

CO1	Identify the national and international standards pertaining to machine drawing.
CO2	Understand the importance of the linking functional and visualization aspects in the preparation of the part drawings
CO3	Apply limits and tolerances to assemblies and choose appropriate fits for given assemblies.
CO4	Interpret the Machining and surface finish symbols on the component drawings.
CO5	Preparation of the part or assembly drawings as per the conventions.

Text Books:

1. **'Machine Drawing',** K.R. Gopala Krishna, Subhash Publication 2005
2. **'Machine Drawing'**, N.D.Bhat & V.M.Panchal. Charoratar publishing house, 2005

Reference books:

1. **A Text Book of Computer Aided Machine Drawing',** S. Trymbaka Murthy, CBS Publishers, New Delhi, 2007.
2. **'Engineering drawing',** P.S.Gill, S K Kataria and Sons. 2013
3. **'Machine Drawing'**, N. Siddeshwar, P. Kanniah, V.V.S. Sastri,published by Tata McGraw Hill,2006

MECHANICAL MEASUREMENTS AND METROLOGY

III / IV SEMESTER

Subject Code	**18 ME 36B/46B**	**CIE Marks**	**40**
Number of Hours/Week	**3L**	**SEE Marks**	**60**
Total Number of Hours	**40**	**Exam Hours**	**3**
No. of Credits: 3			

Course Objectives:

CLO1	To understand the concept of metrology and standards of measurement.
CLO2	To equip with knowledge of limits, fits, tolerances and gauging
CLO3	To acquire knowledge of linear and Angular measurements, Screw thread and gear measurement & comparators.
CLO4	To understand the knowledge of measurement systems and methods with emphasis on different Transducers, intermediate modifying and terminating devices.
CL05	To understand the measurement of Force, Torque, Pressure, Temperature and Strain.

Content	**No. of Hours/RBT levels**
MODULE 1 **Introduction to Metrology:** Definition, objectives of metrology, Material Standards, Wavelength Standards, Classification of standards, Line and End standards, Calibration of End bars. Numerical examples. **Liner measurement and angular measurements:** Slip gauges-Indian standards on slip gauges, Adjustable slip gauges, Wringing of slip gauges, Problems on building of slip gauges (M87, M112), Measurement of angle-sine bar, Sine centre, Angle gauges, Optical instruments for angular measurements. Autocollimator-Applications for measuring straightness and squareness.	**8 Hours** **L1, L2, L3**

MODULE 2 **System of Limits, Fits, Tolerance and Gauging:** Definitions, Tolerance, Tolerance analysis (addition & subtraction of tolerances) Interchangeability & Selective assembly. Class & grade of tolerance, Fits, Types of fits, Numerical on limits, fit and tolerance. Hole base system & shaft base system. Taylor's principle, Types of limit gauges, Numerical on limit gauge design. **Comparators:** Functional requirements, Classification, Mechanical- Johnson Mikrokator, Sigma comparators, Dial indicator, Electrical comparators, LVDT, Pneumatic comparators- Principle of back pressure, Solex comparators, Optical comparators- Zeiss ultra optimeter.	**8 Hours** **L1, L2, L3**
MODULE 3 **Measurement of screw thread and gear:** Terminology of screw threads, Measurement of major diameter, Minor diameter, Pitch, Angle and Effective diameter of screw threads by 2- wire and 3-wire methods, Best size wire. Screw thread gauges, Toolmaker's microscope. **Gear tooth Measurements:** Tooth thickness measurement using constant chord method, Addendum, Comparator method and Base tangent method, Measurement of pitch, Concentricity, Run out and Involute profile. Gear roll tester for composite error.	**8 Hours** **L1, L2, L3**
MODULE 4 **Measurement system and basic concepts of measurement methods:** Definition, Significance of measurement, Generalized measurement system, Static characteristics- Accuracy, Precision, Calibration, Threshold, Sensitivity, Hysteresis, Repeatability, Linearity, Loading effect, Dynamic characteristics- System response, Time delay. Errors in measurement, Classification of errors. **Transducers**: Transfer efficiency, Primary and Secondary transducers, Electrical transducers, Mechanical transducers, Electronic transducers, Relative comparison of each type of transducers. **Intermediate Modifying and Terminating Devices**: Mechanical systems, Inherent problems, Electrical intermediate modifying devices, Input circuitry, Ballast circuit, Electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs.	**8 Hours** **L1, L2, L3**
MODULE 5 **Applied mechanical measurement:** Measurement of force, Torque, Pressure, Types of Dynamometers, Absorption dynamometer, Prony brake and Rope brake dynamometer, and Power Measuring Instruments. Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge. **Measurement of strain and temperature:** Theory of strain gauges, Types, Electrical resistance strain gauge, Preparation and mounting of Strain gauges, Gauge factor, Methods of strain measurement, temperature compensation,	**8 Hours** **L1, L2, L3**

Resistance thermometers, Thermocouple, Law of thermocouple, Pyrometer, Optical pyrometer.	

Corse Outcomes:

After studying this course, students will be able to:

CO1	Understand the objectives of metrology, methods of measurement, standards of measurement & various measurement parameters.
CO2	Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design and also understand the working principle of different types of comparators.
CO3	Describe measurement of major & minor diameter, pitch, angle and effective diameter of screw threads & understand advanced metrology concepts.
CO4	Explain measurement systems, transducers, intermediate modifying devices and terminating devices
CO5	Describe functioning of force, torque, pressure, strain and temperature measuring devices.

TEXT BOOKS:

1) Mechanical Measurements, Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.
2) Instrumentation, Measurement and Analysis, B C Nakra, K K Chaudhry, 4th Edition, McGraw –Hill.
3) Engineering Metrology, R.K. Jain, Khanna Publishers, Delhi, 2009.

REFERENCE BOOKS:

1) Engineering Metrology and Measurements, Bentley, Pearson Education.
2) Theory and Design for Mechanical Measurements,III edition, Richard S Figliola, Donald E Beasley, WILEY India Publishers.
3) Engineering Metrology, Gupta I.C., Dhanpat Rai Publications.
4) Deoblin's Measurement system, Ernest Deoblin, Dhanesh manick, McGraw –Hill.
5) Engineering Metrology and Measurements, N.V.Raghavendra and L.Krishnamurthy, Oxford University Press.

MATERIALS TESTING LAB

III/IV Semester

Course Code	18MEL37 A / 47A	CIE Marks	40
Number of Hours/Week	04 (2T+2P)	SEE Marks	60
Total hours	56	Exam Hours	03
No. of Credits: 2			

CLO1	To learn the concept of the preparation of samples to perform characterization such as microstructure, volume fraction of phases and grain size.
CLO2	To understand mechanical behavior of various engineering materials by conducting standard tests.
CLO3	To learn material failure modes and the different loads causing failure.
CLO4	To learn the concepts of improving the mechanical properties of materials by different methods like heat treatment, surface treatment etc.

Content	No. of Hours/RBT levels
PART – A 1. Preparation of specimen for Metallographic examination of different engineering materials. To report microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites. 2. Heat treatment: Annealing, normalizing, hardening and tempering of steel. Metallographic specimens of heat treated components to be supplied and students should report microstructures of furnace cooled, water cooled, air cooled, tempered steel. Students should be able to distinguish the phase changes in a heat treated specimen compared to untreated specimen. Brinell, Rockwell and Vickers's Hardness tests on untreated and heat treated specimens.	**16 Hours** **L1, L2, L3, L4**

3. To study the defects of Cast and Welded components using Non-destructive tests like: a) Ultrasonic flaw detection b) Magnetic crack detection c) Dye penetration testing.	
PART B 1. Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine 2. Torsion Test on steel bar. 3. Bending Test on steel and wood specimens. 4. Izod and Charpy Tests on Mild steel and C.I Specimen. 5. To study the wear characteristics of ferrous and non-ferrous materials under different parameters. 6. Fatigue Test (demonstration only).	**40 Hours** **L1, L2, L3, L4**

Course Outcomes:

After learning the course, the student should be able to:

CO1	Acquire experimentation skills in the field of material testing.
CO2	Develop theoretical understanding of the mechanical properties of materials by performing experiments.
CO3	Apply the knowledge to analyze a material failure and determine the failure inducing agent/s.
CO4	Apply the knowledge of testing methods in related areas.
CO5	Understand how to improve structure/behavior of materials for various industrial applications.

Scheme of Examination:

ONE question from part -A: 30 Marks
ONE question from part -B: 50 Marks
Viva -Voice: 20 Marks
Total: 100 Marks

MECHANICAL MEASUREMENTS AND METROLOGY LAB

III / IV SEMESTER

Subject Code	**18 MEL 37B/47B**	**CIE Marks**	**40**
Number of Hours/Week	**04 (2T+2P)**	**SEE Marks**	**60**
Total No. of Hours	**56**	**Exam Hours**	**3**
No. of Credits: 2			

COURSE OBJECTIVES:

CLO1	To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
CLO2	To illustrate the use of various measuring tools & measuring techniques.
CLO3	To understand calibration techniques of various measuring devices.

Content	**No. of Hours/ RBT levels**
PART A **MECHANICAL MEASUREMENTS** 1) Calibration of Pressure Gauge 2) Calibration of Thermocouple 3) Calibration of LVDT 4) Calibration of Load cell 5) Determination of modulus of elasticity of a mild steel specimen using strain gauges.	**20 Hours** L2, L3, L4
PART B **METROLOGY** 6) Measurements using Optical Projector / Toolmakers' Microscope. 7) Measurement of angle using Sine Centre / Sine bar / bevel protractor 8) Measurement of alignment using Autocollimator / Roller set	**36 Hours** L2, L3, L4

9) Measurement of cutting tool forces using a) Lathe tool Dynamometer b) Drill tool Dynamometer. 10) Measurements of Screw thread parameters using two wire or three-wire methods. 11) Measurements of surface roughness using Tally Surf/Mechanical Comparator 12) Measurement of gear tooth profile using gear tooth Vernier/Gear tooth micrometer 13) Calibration of Micrometer using slip gauges 14) Measurement using Optical Flats	

Corse Outcomes:

After studying this course, students will be able to:

CLO1	To calibrate pressure gauge, thermocouple, LVDT, load cell, micrometer.
CLO2	To measure angle using Sine Centre/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.
CLO3	To demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.
CLO4	To measure cutting tool forces using Lathe/Drill tool dynamometer.
CLO5	To measure Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometer.
CL06	To measure surface roughness using Tally Surf/ Mechanical Comparator.

Scheme of Examination:
ONE question from part -A: 30 Marks

ONE question from part-B: 50 Marks

Viva -Voice: 20 Marks

Total: 100 Marks

WORKSHOP AND MACHINE SHOP PRACTICE

III/IV Semester

Course Code	18**MEL38A/ 48A**	**CIE Marks**	**40**
Number of Hours / Week	**04 (2T+2P)**	**SEE Marks**	**60**
Total Number of hours	**56**	**Exam Hours**	**03**
No. of Credits: 2			

Course Objectives:

CLO1	To guide students to use fitting tools to perform fitting operations.
CLO2	To provide an insight to different machine tools, accessories and attachments.
CLO3	To train students into fitting and machining operations to enrich their practical skills.
CLO4	To inculcate team qualities and expose students to shop floor activities.
CL05	To educate students about ethical, environmental and safety standards.

Content	**No. of Hours/RBT levels**
Part A Preparation of at least two fitting joint models by proficient handling and application of hand tools- V-block, marking gauge, files, hack saw drills etc.	**12 Hours** **L1, L2, L3, L4**
Part B Preparation of three models on lathe involving - Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning. Exercises should include selection of cutting parameters and cutting time estimation.	**32 Hours** **L1, L2, L3, L4**

Part C	12 Hours
Cutting of V Groove/ dovetail / Rectangular groove using a shaper. Cutting of Gear Teeth using Milling Machine. Exercises should include selection of cutting parameters and cutting time estimation.	**L1, L2, L3, L4**

COURSE OUTCOMES:

On completion of this subject students will be able to:

CO1	To read working drawings, understand operational symbols and execute machining operations.
CO2	Prepare fitting models according to drawings using hand tools- V-block, marking gauge, files, hack saw, drills etc.
CO3	Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used thereof.
C04	Select cutting parameters like cutting speed, feed, depth of cut, and tooling for various machining operations.
CO5	Perform cylindrical turning operations such as plain turning, taper turning, step turning, thread Cutting, facing, knurling, internal thread cutting, eccentric turning and estimate cutting time.
C06	Perform machining operations such as plain shaping, inclined shaping, keyway cutting, Indexing and Gear cutting and estimate cutting time.

Scheme of Examination:

One Model from Part-A or Part-C	30 Marks
One Model from Part-B	50 Marks
Viva – Voce	20 Marks
TOTAL	100 Marks

Foundry, Forging and Welding Lab

SEMESTER – III/IV

Subject Code	**18MEL 38B/48B**	**CIE Marks**	**40**
Hours / Week	**02T+02P**	**SEE Marks**	**60**
Total Hours	**56**	**Exam Hours**	**03**
No. of Credits: 2			

Course objectives:

CLO1	To provide an insight into different sand preparation and foundry equipments.
CLO2	To provide an insight into different forging tools and equipments and arc welding tools and equipments.
CLO3	To provide training to students to enhance their practical skills in welding, forging and hand moulding.
CLO4	To practically demonstrate precautions to be taken during casting, hot working and welding operations.

Content	No. of Hours
PART-A **Testing of Molding sand and Core sand.** **Preparation of sand specimens and conduction of the following tests:** 1. Compression, Shear and Tensile tests on Universal Sand Testing Machine. 2. Permeability test 3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand 4. Clay content determination on Base Sand. **Welding Practice:** Use of Arc welding tools and welding equipment Preparation of welded joints using Arc Welding equipment L-Joint, T-Joint, Butt joint, V-Joint, Lap joints on M.S. flats	**16 Hours** **L2, L3, L4**
Part-B	
Foundry Practice: **Use of foundry tools and other equipment for Preparation of molding sand mixture.** **Preparation of green sand molds kept ready for pouring in the following cases:** 1. Using two molding boxes (hand cut molds). 2. Using patterns (Single piece pattern and Split pattern). • Incorporating core in the mold. (Core boxes). • Preparation of one casting (Aluminum or cast iron-Demonstration only)	**20 Hours** **L2, L3, L4**
Part-C	
Forging Operations: Use of forging tools and other forging equipment. • Calculation of length of the raw material required to prepare the model considering scale loss. • Preparing minimum three forged models involving upsetting, drawing and bending operations.	**20 Hours** **L2, L3, L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Demonstrate various skills in preparation of molding sand for conducting tensile, shear and compression tests using Universal sand testing machine.
CO2	Demonstrate skills in determining permeability, clay content and Grain Fineness Number of base sands.
CO3	Demonstrate skills in preparation of forging models involving upsetting, drawing and bending operations.
CO4	Demonstrate skills in preparation of various welding joints on M.S flats using Arc welding equipment.

Question paper pattern:

1. **One question is to be set from Part-A - Procedure+ Execution: 5+25=30 marks**
2. **One question is to be set from either Part-B or Part-C: 50 Marks**
3. **Viva – Voce: 20 marks**

Total: (30+40+10+20) = 100 marks

IV SEMESTER MECHANICAL 2018 SCHEME

APPLIED THERMODYNAMICS

IV Semester

Course Code	18ME42	CIE Marks	40
Number of Lecture Hours/Week	3L+2T	SEE Marks	60
Total Number of Lecture Hours	70	Exam Hours	03
No. of Credits: 4			

Module 1	10 Hours	(L1, L2, L3)

Gas Power Cycles: Air standard cycles; Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles.

Module 2	10 Hours	(L1, L2, L3, L4)

Vapour Power Cycles: Carnot vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-S diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Characteristics of an Ideal working fluid in vapour power cycles.

Module 3	10 Hours	(L1, L2, L3, L4)

Combustion Thermodynamics: Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency.

I.C.Engines: Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, Heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels.

Module 4	10 Hours	(L2, L3, L4)

Refrigeration Cycles: Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle, vapour absorption refrigeration system.

Pscychrometrics and Air-conditioning Systems: Psychometric properties of Air, Psychometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of two moist air streams. Cooling towers.

Module 5	10 Hours	(L2, L3, L4)

Reciprocating Compressors: Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression.

Steam nozzles: Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.

Course outcomes:

- Apply thermodynamic concepts to analyze the performance of gas power cycles.
- Apply thermodynamic concepts to analyze the performance of vapour power cycles.
- Understand combustion of fuels and performance of I C engines.
- Understand the principles and applications of refrigeration systems.
- Apply Thermodynamic concepts to determine performance parameters of refrigeration and air-conditioning systems.
- Understand the working principle of Air compressors and Steam nozzles, applications, relevance of air and identify methods for performance improvement.

TEXT BOOKS:

1. Engineering Thermodynamics" by P.K. Nag, Tata McGraw Hill, 6th Edition 2018.
2. Applications of Thermodynamics by V Kadambi, T R Seetharam, K B Subramanya Kumar, Wiley Indian Private Ltd., 1st Edition 2019
3. Thermodynamics by Yunus A Cengel, Michael A Boles, Tata McGraw Hill, 7th Edition.

REFERENCE BOOKS

1. Thermodynamics for engineers, Kenneth A. Kroos and Merle C. Potter, Cengage Learning, 2016
2. Principles of Engineering Thermodynamics, Michael J, Moran, Howard N. Shapiro, Wiley, 8th Edition
3. An Introduction to Thermo Dynamics by Y.V.C.Rao, Wiley Eastern Ltd, 2003.
4. Thermodynamics by Radhakrishnan. PHI, 2nd revised edition.
5. I.C Engines by Ganeshan.V. Tata McGraw Hill, 4rth Edi. 2012.
6. I.C.Engines by M.L.Mathur & Sharma. Dhanpat Rai& sons- India

Fluid Mechanics

IV Semester

Subject Code	18 ME43	CIE Marks	40
Number of Hours/Week	3L	SEE Marks	60
Total Number of Hours	40	Exam Hours	3
No. of Credits – 3			

Course Objectives:

CLO1	To have a working knowledge of the basic properties of fluids and understand the continuum approximation.
CLO2	To calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy.
CLO3	To understand the flow characteristic and dynamics of flow field for various engineering applications.
CLO4	To know how velocity changes and energy transfers in fluid flows are related to forces and torques and to understand why designing for minimum loss of energy in fluid flows is so important.
CL05	To discuss laminar and turbulent flow and appreciate their differences and the concept of boundary layer theory.
CL06	To understand the concept of dynamic similarity and how to apply it to experimental modeling.
CL07	To appreciate the consequences of compressibility in gas flow and understand the effects of friction and heat transfer on compressible flows.

Content	No. of Hours/RBT levels
MODULE 1 **Basics:** Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc., pressure at a point in the static mass of fluid, variation of pressure. Pascal's law, absolute, gauge, atmospheric and vacuum pressures; pressure measurement by simple, differential manometers and mechanical gauges. **Fluid Statics:** Total pressure and center of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid. Buoyancy, center of buoyancy, meta center and meta centric height its application.	**8 Hours** **L1, L2, L3**

MODULE 2 **Fluid Kinematics and Dynamics:** Velocity of fluid particle, types of fluid flow, description of flow, continuity equation, Coordinate free form, acceleration of fluid particle, rotational & irrotational flow, Laplace's equation in velocity potential and Poisson's equation in stream function, flow net,. Momentum equation, Impact of jets-force on fixed and moving vanes, flat and curved. Development of Euler's equation, introduction to Navier-Stokes equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem- venture meter, orifice meter, rectangular and triangular notch, pitot tube, orifices etc.	**8 Hours** **L1, L2, L3**
MODULE 3 **Laminar and turbulent flow**: Flow through circular pipe, between parallel plates, power absorbed in viscous flow in bearings, Poiseuille equation – velocity profile. Couette flow and Plane Poiseuille flow, loss of head due to friction in viscous flow. Reynolds's experiment, frictional loss in pipe flow. Introduction to turbulence, characteristics of turbulent flow, laminar-turbulent transition, correlation functions, the mean motion and fluctuations, shear stress in turbulent flow, major and minor losses, use of Moody diagram HGL and TEL.	**8 Hours** **L1, L2, L3**
MODULE 4 **Flow over bodies**: Development of boundary layer, Prandtl‟s boundary layer equations, Blasius solution, integral momentum equation, drag on a flat plate, boundary layer separation and its control, streamlined and bluff bodies -flow around circular bodies and aero foils, calculation of lift and drag. **Dimensional analysis**: Introduction, derived quantities, dimensions of physical quantities, dimensional homogeneity, Rayleigh's method, Buckingham Pi-theorem, dimensionless numbers, similitude, types of similitude.	**8 Hours** **L1, L2, L3**
MODULE 5 **Compressible Flows:** Introduction, thermodynamic relations of perfect gases, internal energy and enthalpy, speed of sound, pressure field due to a moving source, basic Equations for one-dimensional flow, stagnation and sonic properties, normal and oblique shocks. **Introduction to CFD**: Necessity, limitations, philosophy behind CFD, applications.	**8 Hours** **L1, L2, L3**

Corse Outcomes:

After studying this course, students will be able to:

CO1	Identify and calculate the key fluid properties used in the analysis of fluid behavior.
CO2	Explain the principles of pressure, buoyancy and floatation
CO3	Apply the knowledge of fluid statics, kinematics and dynamics while addressing problems of mechanical and chemical engineering.
CO4	Describe the principles of fluid kinematics and dynamics.
CO5	Explain the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables.
CO6	Illustrate and explain the basic concept of compressible flow and CFD

Text Books:

1. Fluid Mechanics (SI Units), Yunus A. Cengel John M.Cimbala, 3rd Ed., Tata McGraw Hill, 2014.
2. Mechanics of Fluids, Merle C. Potter, Devid C. Wiggerrt, Bassem H. Ramadan, Cengage learning, Fourth editions 2016.

Reference Books:

1. Fluid Mechanics, F M White, McGraw Hill Publications Eighth edition. 2016
2. Fundamentals of Fluid Mechanics by Munson, Young, Okiishi& Huebsch, John Wiley Publications.7th edition.
3. Fluid Mechanics, Pijush.K.Kundu, IRAM COCHEN, ELSEVIER, 3rd Ed. 2005.
4. Fluid Mechanics, John F.Douglas, Janul and M.Gasiosek and john A.Swaffield, Pearson Education Asia, 5th ed., 2006.
5. Introduction to Fluid Mechanics by Fox, McDonald, John Wiley Publications,8th edition.

E- Learning

- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

Kinematics of Machines

IV Semester

Subject Code	**18ME44**	**CIE Marks**	**40**
Number of Hours/Week	**3L**	**SEE Marks**	**60**
Total Number of Hours	**3**	**Exam. Hours**	**03**
Number of Credits: 3			

Course objectives:

CLO1	To understand the concept of machines, mechanisms and related terminologies.
CLO2	To expose the students to various mechanisms and motion transmission elements used in Mechanical Engineering.
CLO3	To analyze a mechanism for displacement, velocity and acceleration at any point in a moving link.
CLO4	To understand the theory of cams, gears and gear trains.

Content	**Hours/ Blooms Level**
Module 1 **Mechanisms:** Definitions: Link , types of links, joint, types of joints kinematic pairs, Constrained motion, kinematic chain, mechanism and types , degrees of freedom of planar mechanisms, Equivalent mechanisms, Groshoff's criteria and types of four bar mechanisms, , inversions of of four bar chain, slider crank chain, Doubler slider crank chain and its inversions, Grashoff's chain. Mechanisms: Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Straight line motion mechanisms, Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, condition for correct steering, Ackerman steering gear mechanism.	**9 Hrs** **L1,L2**
Module 2 **Velocity and Acceleration Analysis of Mechanisms (Graphical Method):** Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing. Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method.	**9Hrs** **L2,L3**
Module 3 **Velocity and Acceleration Analysis of Mechanisms (Analytical Method):** Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method. Freudenstein's equation for four bar mechanism and slider crank mechanism. Function Generation for four bar mechanism.	**07 Hours** **L2,L3,L4**
Module 4	**08 Hours** **L1, L2,L3**

Cams: Classification of cams, Types of followers, Cam nomenclature, Follower motions and motion analysis, of SHM, Motion with uniform acceleration and deceleration, uniform velocity, cycloidal motion, Cam profile with offset knife edge follower, roller follower, flat faced follower.	
Module 5 **Spur Gears:** Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, condition and expressions for minimum number of teeth to avoid interference. **Gear Trains:** Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains.	**07 Hours** **L1,L2,L3,L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Knowledge of mechanisms and their motion.
CO2	Understand the inversions of a four bar mechanisms.
CO3	Analyse the velocity, acceleration of links and joints of mechanisms.
CO4	Analysis of cam follower motion for the motion specifications.
CO5	Understand the working of the spur gears.
CO6	Analyse the gear trains speed ratio and torque.

Text Books:

1. Sadhu Singh, Theory of Machines: Kinematics and Dynamics, Third edition,, Pearson,2019.
2. G. Ambekar, Mechanism and Machine Theory, PHI, 2009.

Reference Books:

1. Rattan S.S, Theory of Machines, Tata McGraw-Hill Publishing Company, 2014.
2. Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016.

V SEMESTER MECHANICAL 2018 SCHEME

Management and Economics

V SEMESTER

Subject Code	**18ME51**	**CIE Marks**	**40**
Hours / Week	**2L+2T**	**SEE Marks**	**60**
Total Hours	**50**	**Exam Hours**	**03**
No. Of Credits:3			

Content	**No. of Hours/RBT levels**
Module 1 Management: Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as a science, art of profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought- early management approaches – Modern management approaches. Planning: Nature, importance and purpose of planning process Objectives -Types of plans (Meaning Only) - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans.	**10 Hours** **L1, L2, L3**
Module 2 Organizing And Staffing: Nature and purpose of organization Principles of organization - Types of organization - Departmentation Committees Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE (Meaning Only) Nature and importance of staffing--Process of Selection & Recruitment (in brief). Directing & Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co Ordination. Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief).	**10 Hours** **L1, L2, L3**
Module 3 Introduction: Engineering and economics, Problem solving and decision making, Laws of demand and supply, Difference between Microeconomics & Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, income elasticity. Law of Returns, Interest and interest factors,	**10 Hours** **L1, L2, L3, L4**

simple and compound interest, Cash flow diagrams, personal loans and EMI payment calculation with flexible interest rates, Discussion and problems.	
Module 4 Present, future and annual worth and rate of returns: Basic present worth comparisons, Present worth-equivalence, Assets with unequal lives and infinites lives, future worth comparisons, payback comparisons, Equivalent annual worth comparisons, situations for annual worth comparisons. Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Discussions and problems.	**10 Hours** **L1, L2, L3, L4**
Module 5 Costing and depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems.	**10 Hours** **L1, L2, L3, L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Understand needs, functions, roles, scope and evolution of Management
CO2	Understand importance, purpose of Planning and hierarchy of planning and also analyze its types.
CO3	Discuss Decision making, Organizing, Staffing, Directing and Controlling.
C04	Select the best economic model from various available alternatives.
C05	Understand various interest rate methods and implement the suitable one.
C06	Estimate various depreciation values of commodities
C07	Prepare the project reports effectively.

TEXTBOOKS:

1. Mechanical estimation and costing, T.R. Banga& S.C. Sharma, 17th edition 2015
2. Engineering Economy, Riggs J.L. McGraw Hill, 2002
3. Engineering Economy, Thuesen H.G. PHI , 2002
4. Principles of Management by Tripathy and Reddy

REFERENCES:

1. Management Fundamentals- Concepts, Application, Skill Development - RobersLusier – Thomson
2. Basics of Engineering Economy, Leland Blank & Anthony Tarquin, McGraw Hill Publication (India) Private Limited
3. Engineering Economics, R.Paneerselvam, PHI publication
4. Fundamentals of Management: Essential Concepts and Applications, Pearson Education, Robbins S.P. and Decenzo David A.
5. Economics: Principles of Economics, N Gregory Mankiw, Cengage Learning
6. Modern Economic Theory, By Dr. K. K. Dewett& M. H. Navalur, S. Chand Publications

DESIGN OF MACHINE ELEMENTS I
SEMESTER – V

Subject Code	**18ME 52**	**CIE Marks**	**40**
Hours/Week	**3L +2T**	**SEE Marks**	**60**
Total Hours	**70**	**Exam Hours**	**03**
No. of Credits: 4			

Course Objectives:

CLO1	To understand the various steps involved in the Design Process.
CLO2	To explain the principles involved in design of machine elements, subjected to different kinds of forces, from the considerations of strength, rigidity, functional and manufacturing requirements.
CLO3	To understand and interpret different failure modes and application of appropriate criteria for design of machine elements.
CLO4	To learn to use national and international standards, standard practices, standard data, catalogs, and standard components used in design of machine elements.
CLO5	Develop the capability to design elements like shafts, couplings, welded joints, screwed joints, and power screws.

Content	**No. of Hours/RBT levels**
MODULE I **Introduction** Design Process: Definition of design, phases of design, and review of engineering materials and their properties and manufacturing processes; use of codes and standards, selection of preferred sizes. Review of axial, bending, shear and torsion loading on machine components, combined loading, two- and three dimensional stresses, principal stresses, stress tensors, Mohr's circles. **Design for static strength** Factor of safety and service factor. Failure mode: definition and types. Failure of brittle and ductile materials; even and uneven materials; Theories of failure: maximum normal stress theory, maximum shear stress theory, distortion energy theory, strain energy theory, Columb –Mohr theory and modified Mohr's theory. Stress concentration, stress concentration factor and methods of reducing stress concentration.	**10 Hours** **L1, L2, L3, L4**
MODULE 2 **Impact Strength** Introduction, Impact stresses due to axial, bending and torsion loads. **Fatigue loading** Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit.	**10 Hours** **L1, L2, L3, L4**

Modifying factors: size effect, surface effect, Stress concentration effects, Notch sensitivity, Soderberg and Goodman relationships, stresses due to combined loading, cumulative fatigue damage, and Miner's equation.	
MODULE 3 **Design of shafts** Torsion of shafts, solid and hollow shaft design with steady loading based on strength and rigidity, ASME and BIS codes for power transmission shafting, design of shafts subjected to combined bending, torsion and axial loading. Design of shafts subjected to fluctuating loads. **Design of keys and couplings** Keys: Types of keys and their applications, design considerations in parallel and tapered sunk keys, Design of square and rectangular sunk keys. Couplings: Rigid and flexible coupling-types and applications, design of Flange coupling, and Bush and Pin type coupling.	**10 Hours** **L1, L2, L3, L4**
MODULE 4 **Design of Permanent Joints:** Types of permanent joints-Riveted and Welded Joints. **Riveted joints:** Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints, riveted brackets. **Welded joints:** Types, strength of butt and fillet welds, eccentrically loaded welded joints.	**10 Hours** **L1, L2, L3, L4**
MODULE 5 **Design of Temporary Joints:** Types of temporary joints- cotter joints, knuckle joint and fasteners. Design of Cotter and Knuckle Joint. **Threaded Fasteners** Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints. **Power screws** Mechanics of power screw, stresses in power screws, efficiency and self-locking, design of power screws.	**10 Hours** **L1, L2, L3, L4**

Assignment:

Course work includes a **Design project**. Design project should enable a group of students (maximum four in a group) to design a mechanical system (like couplings, screw jack, welded joints, bracket mounting using fasteners, etc.). Student should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report.

Design project should be given due credit in internal assessment.

Course Outcomes:

After learning the course, the student should be able to:

CO1	**Apply** the concepts of selection of materials for given mechanical components.
CO2	**List** the functions and uses of machine elements used in mechanical systems.
CO3	**Apply** codes and standards in the design of machine elements and **select** an element based on the manufacturer's catalog.
CO4	**Analyze** the performance and failure modes of mechanical components subjected to combined loading and fatigue loading using the concepts of theories of failure.
CO5	**Demonstrate** the application of engineering design tools to the design of machine components like shafts, couplings, power screws, fasteners, welded and riveted joints.
CO6	**Understand** the art of working in a team.

Textbooks:

[1] Richard G. Budynas, and J. Keith Nisbett, **"**Shigley's Mechanical Engineering Design**",** McGraw-Hill Education, 10th Edition, 2015.

[2] Juvinall R.C, and Marshek K.M, "Fundamentals of Machine Component Design", John Wiley & Sons, Third Edition, Wiley student edition, 2007.

[3] V B Bhandari, *Design of Machine Elements*, 4th Ed., Tata Mcgraw Hill, 2016.

References:

[1] Robert L. Norton "Machine Design- an integrated approach", Pearson Education, 2nd edition.

[2] Spotts M.F., Shoup T.E "Design and Machine Elements", Pearson Education, 8th edition,2006.

[3] Orthwein W, "Machine Component Design", Jaico Publishing Co, 2003.

[4] Hall, Holowenko, Laughlin (Schaum's Outline series), "Machine Design", adapted by S.K.Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

[5] H.G.Patil, S.C.Pilli, R.R.Malagi, M.S.Patil., "Elements of Machine Design", IK International, First edition,2019.

[6] T. Krishna Rao, Design of Machine Elements, Volume I, 2012, IK international publishing house, New Delhi.

[7] G. M. Maithra and L.V.Prasad, "Hand book of Mechanical Design", Tata McGraw Hill, 2nd edition, 2004.

Design Data Hand Book:

[1] Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.

[2] Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.

[3] Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010

[4] PSG Design Data Hand Book, PSG College of technology, Coimbatore.

Dynamics of Machines
V Semester

Subject Code	**18ME53**	**CIE Marks**	**40**
Number of Hours/Week	**3L+2T**	**SEE Marks**	**60**
Total Number of Hours	**70**	**Exam. Hours**	**03**
Number of Credits: 4			

Content	**Hours/ Blooms Level**
Unit I: Static force analysis: Static equilibrium, analysis of four bar mechanism, slider crank mechanism, shaper mechanism. **Dynamic force analysis:** D'lemberts principle, analysis of four bar and slider crank mechanism, shaper mechanism.	**10Hrs** L1,L2,L3,
Unit II: Balancing of Rotating Masses: Static and Dynamic Balancing, Balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes. **Balancing of Reciprocating Masses:** Inertia Effect of crank and connecting rod, Single cylinder Engine, Balancing in multi cylinder-inline engine (primary and secondary forces), V-type engine, Radial engine – direct and reverse crank method.	**10Hrs** L1,L2,L3, L4
UNIT III: Governors: Types of Governors; Force Analysis of Porter and Hartnell Governors. Controlling Force, Stability, Sensitiveness, Isochronism, Effort and Power. **Gyroscope :** Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic Couple on plane disc, ship, aeroplane, Stability of two wheelers and four wheelers.	**10Hrs** L1,L2,L3, L4
Module-IV: Free vibrations: Basic elements of vibrating system, Types of free vibrations, Longitudinal vibrations-Equilibrium method, D'Alembert's principle, Energy method, Rayleigh's method. Determination of natural frequency of single degree freedom systems, Effect of spring mass, Damped free vibrations: Under damped, over damped and critically damped systems. Logarithmic decrement.	**10 Hrs** L1,L2,L3
Module V: Forced vibrations: Undamped forced vibration of spring mass system, Damped forced vibrations, Rotating unbalance, Reciprocating unbalance, Vibration isolation, Support motion(absolute and relative motion), Transverse vibration of shaft with single concentrated load, several loads, uniformly distributed load, Critical speed.	**10Hrs.** L1,L2,L3

Text Books:

1. Sadhu Singh, Theory of Machines: Kinematics and Dynamics, Third edition,, Pearson,2019.
2. G. Ambekar, Mechanism and Machine Theory, PHI, 2009.

Reference Books:

1. Rattan S.S, Theory of Machines, Tata McGraw-Hill Publishing Company, 2014.
2. Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016.

Course Outcomes:

After completion of the course, the student should be able to:

CO1	Analyse the mechanisms for static and dynamic equilibrium.
CO2	Carry out the balancing of rotating and reciprocating masses
CO3	Analyse different types of governors used in real life situation.
CO4	Analyse the gyroscopic effects on disks, airplanes, stability of ships, two and four wheelers
CO5	Understand the free and forced vibration phenomenon.
CO6	Determine the natural frequency, force and motion transmitted in vibrating systems.

TURBO MACHINES

V SEMESTER

Course Code	**18ME54**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**03L**	**SEE Marks**	**60**
Total Number of Lecture Hours	**40(8 Hours per Module)**	**Exam Hours**	**03**

Credits – 03

Course Objectives:

- Understand typical design of Turbo machine, their working principle, application and thermodynamics process involved.
- Study the conversion of fluid energy to mechanical energy in Turbo machine with utilization factor and degree of reaction.
- Analyze various designs of steam turbine and their working principle.
- Study the various designs of hydraulic turbine based on the working principle.
- Understand the various aspects in design of power absorbing machine.

Module - 1

Introduction: Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Unit and specific quantities, model studies and its numerical.

(Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)

Thermodynamics of fluid flow: Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process. Simple Numerical on stage efficiency and polytropic efficiency.

Module - 2

Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems.

General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, , General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Numerical Problems.

Module - 3

Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor, Numerical Problems.

Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Numerical Problems

Module - 4

Hydraulic Turbines: Classification, various efficiencies.

Pelton Wheel – Principle of working, velocity triangles, design parameters, maximum efficiency, and numerical problems.

Francis turbine – Principle of working, velocity triangles, design parameters, and numerical problems

Kaplan and Propeller turbines - Principle of working, velocity triangles, design parameters and Numerical Problems.

Theory and types of Draft tubes.

Module - 5

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Theoretical head – capacity relationship, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems.

Course outcomes:

- Model studies and thermodynamics analysis of turbomachines
- Analyse the energy transfer in Turbo machine with degree of reaction and utilisation factor
- Classify, analyse and understand various type of steam turbine.
- Classify, analyse and understand various type of hydraulic turbine.
- Understand the concept of radial power absorbing machine and the problems involved during its operation.

TEXT BOOKS:

1. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008.
2. Turbo Machines , B.U.Pai , 1st Editions, Wiley India Pvt, Ltd.
3. Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd., 2nd edition, 2002

REFERENCE BOOKS

1. Text Book of Turbo machines, M. S. Govindegouda and A. M. Nagaraj, M. M. Publications, 7Th Ed, 2012.
2. Principals of Turbo machines, D. G. Shepherd, The Macmillan Company (1964).
3. Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier (2005).

FLUID POWER ENGINEERING
SEMESTER – V

Subject Code	**18ME55**	**CIE Marks**	**40**
Hours/Week	**03**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits: 3			

Course objectives:

CLO1	To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
CLO2	To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
CLO3	To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
CLO4	Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
CLO5	To familiarize with logic controls and trouble shooting.

Content	**No. of Hours/RBT levels**
Module 1 Introduction to fluid power systems Fluid power system: components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications. Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers; sources of contamination and contamination control; heat exchangers.	**8 Hours** **L1, L2, L3**
Module 2 **Pumps and actuators** **Pumps:** Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and	**8 Hours** **L2, L3, L4**

variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps. **Accumulators:** Types, and applications of accumulators. Types of Intensifiers, Pressure switches /sensor, Temperature switches/sensor, Level sensor. **Actuators:** Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders. Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power, flow rate, and hydraulic motor performance; numerical problems. Symbolic representation of hydraulic actuators (cylinders and motors).	
Module 3 **Components and hydraulic circuit design Components:** Classification of control valves, Directional Control Valves-symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves. Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation. **Hydraulic Circuit Design:** Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, counter balance valve application, hydraulic cylinder sequencing circuits, hydraulic circuit for force multiplication; speed control of hydraulic cylinder- metering in, metering out and bleed off circuits. Pilot pressure operated circuits.	**8 Hours** **L2, L3, L4**
Module 4 **Pneumatic power systems** Introduction to Pneumatic systems: Pneumatic power system, advantages, limitations, applications, Choice of working medium. Characteristics of compressed air and air compressors. Structure of pneumatic control System, fluid conditioners-dryers and FRL unit. Pneumatic Actuators: Linear cylinder – types of cylinders, working, end position cushioning, seals, mounting arrangements, and applications. Rotary cylinders- types, construction and application, symbols. **Pneumatic Control Valves:** DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of	**8 Hours** **L2, L3, L4**

memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols.	
Module 5 **Pneumatic control circuits** **Simple Pneumatic Control:** Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling. **Signal Processing Elements:** Use of Logic gates - OR and AND gates in pneumatic applications. Practical examples involving the use of logic gates. **Multi- Cylinder Application:** Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method- principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves). **Electro- Pneumatic Control:** Principles - signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple signal cylinder application.	**8 Hours** **L2, L3, L4**

Learning Assignment:

The faculty will allocate one or more of the following experiments from group A and B to group of students (containing not more than four students in a group):

Group A: Experiments on hydraulic trainer:

a. Speed control circuit using metering in and metering out technique
b. Regenerative and sequencing circuits.
c. Extend-Retract and Stop system of a linear actuator
d. Rapid Traverse and Feed circuit.

Group B: Experiments on pneumatic trainer:

a. Automatic reciprocating circuit
b. Speed control circuit
c. Pneumatic circuit involving shuttle valve/ quick exhaust valve
d. Electro pneumatic valves and circuit

Students should build up the above circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the hydraulic/pneumatic trainer and run the circuit. Record of experiments shall be submitted in the form of journal. Due credit must be given for this assignment.

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Identify and analyse the functional requirements of a fluid power transmission system for a given application.
CO2	Visualize how a hydraulic/pneumatic circuit will work to accomplish the function.

CO3	Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro-pneumatics for a given application.
CO4	Select and size the different components of the circuit.
CO5	Develop a comprehensive circuit diagram by integrating the components selected for the given application.

TEXT BOOKS:

1. Anthony Esposito, "Fluid Power with applications", Pearson edition,2000 .
2. Majumdar S.R., "Oil Hydraulics", Tala McGRaw HllL, 2002 .
3. Majumdar S.R., "Pneumatic systems - Principles and Maintenance", Tata McGraw-Hill, New Delhi, 2005

REFERENCE BOOKS:

1. John Pippenger, Tyler Hicks, "Industrial Hydraulics", McGraw Hill International Edition, 1980.
2. Andrew Par, Hydraulics and pneumatics, Jaico Publishing House, 2005.
3. FESTO, Fundamentals of Pneumatics, Vol I, II and III.
4. Herbert E. Merritt, "Hydraulic Control Systems", John Wiley and Sons, Inc.
5. Thomson, Introduction to Fluid power, Prentcie Hall, 2004
6. John Watton, "Fundamentals of fluid power control", Cambridge University press, 2012.

List of Open Source Software/learning website:

1. Simulink
2. SimHydraulics

OPERATIONS MANAGEMENT

V Semester

Course Code	**18ME56**	**CIE Marks**	**40**
Number of Hours/Week	**3L**	**SEE Marks**	**60**
Total Number of Hours	**40**	**Exam Hours**	**3**
No. of Credits – 3			

Content	No. of Hours/RBT levels
MODULE 1 Introduction, Functions within business organizations, the operation management function, Classification of production systems, Productivity, factors affecting productivity. **Decision Making:** The decision process, characteristics of operations decisions, use of models, decision making environments, graphical linear programming, analysis and trade-offs.	
MODULE 2 **Forecasting:** Steps in forecasting process, approaches to forecasting, forecasts based on judgment and opinion, analysis of time series data, accuracy and control of forecasts, choosing a forecasting technique, elements of a good forecast.	
MODULE 3 **Capacity & Location Planning:** Importance of capacity decisions, defining and measuring capacity, determinants of effective capacity, determining capacity requirement, developing capacity alternatives, evaluating alternatives, Need for location decisions, nature of locations decisions, general procedure for making locations decisions, evaluating locations decisions, facilities layout – need for layout decisions, types of processing	
MODULE 4 **Aggregate Planning & Master Scheduling:** Aggregate planning – Nature and scope of aggregate planning, strategies of aggregate planning, techniques for aggregate planning – graphical and charting techniques, mathematical techniques. The master production schedule, Master scheduling process, Master scheduling methods.	

MODULE 5	
Material Requirement Planning (MRP): Dependent versus independent demand, an overview of MRP – MRP inputs and outputs, MRP processing, ERP capacity requirement planning, benefits and limitations of MRP. **Purchasing and Supply Chain Management (SCM):** Introduction, Importance of purchasing and SCM, the procurement process, Concept of tenders, Approaches to SCM, Vendor development.	

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1. Explain the concept and scope of operations management in a business context

CO2. Recognize the role of Operations management among various business functions and its role in the organizations' strategic planning and gaining competitive advantage.

CO3. Analyze the appropriateness and applicability of a range of operations management systems/models in decision making.

CO4. Assess a range of strategies for improving the efficiency and effectiveness of organizational operations.

CO5. Evaluate a selection of frameworks used in the design and delivery of operations

TEXT BOOKS:

1. Production and Operations Management, William J Stevenson, 9 th Ed., Tata McGraw Hill.
2. Operations Management David A Collier,James R Evans,Kunal Ganguly Cengage Learning India Pvt. Limited 3rd Edition 2016, ISBN-13:978-81-315-2809-9

REFERENCE BOOKS:

1 Lee J Karjewski and Larry P Ritzman, Manoj Malhotra, Operations Management – Processes and Supply Chain, Pearson Education Asia, 11th Edn, 2010, ISBN: 0133872467, 9780133872460

2 R. Paneerselvam, Production and Operations Management, PHI, 2nd Edn, 2006, ISBN:81-203-2767-5

3 B. Mahadevan, Operations Management – Theory and Practice, PHI, 2010, 2nd Edn, ISBN: 978 8131730706

Fluid Mechanics and Machinery Lab

V Semester

Subject Code	**18MEL57**	**CIE Marks**	**40**
Number of Hours/Week	**2LT +2P**	**SEE Marks**	**60**
Total Number of Hours	**56**	**Exam Hours**	**03**

Credits: 02

Course Objectives:

1. This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
2. Energy conversion principles, analysis and understanding of hydraulic turbines and pumps will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.

PART A

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of coefficient of friction of flow in a pipe.
3. Determination of minor losses in flow through pipes.
4. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades
5. Calibration of flow measuring devices.
   Orifice meter, Nozzle, Venturimeter, V-notch.

PART B

7. Performance on hydraulic Turbines a. Pelton wheel b. Francis Turbine c. Kaplan Turbines
8. Performance hydraulic Pumps d. Single stage and Multi stage centrifugal pumps e. Reciprocating pump.
9. Performance test on a two stage Reciprocating Air Compressor.
10. Performance test on an Air Blower.

PART C (Optional)

11. Visit to Hydraulic Power station/ Municipal Water Pump House and Case Studies

12. Demonstration of cut section models of Hydraulic turbines and Pumps.

Course outcomes:

1. Perform experiments to determine the coefficient of discharge of flow measuring devices.
2. Conduct experiments on hydraulic turbines and pumps to draw characteristics.
3. Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
4. Determine the energy flow pattern through the hydraulic turbines and pumps

5. Exhibit his competency towards preventive maintenance of hydraulic machines
Reading: 1. K.L.Kumar."Engineering Fluid Mechanics" Experiments, Eurasia Publishing House, 1997 2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995 3.George E. Totten , Victor J. De Negri "Handbook of Hydraulic Fluid Technology, Second Edition, 2011.
Scheme of Examination: ONE question from part –A : 30 Marks ONE question from part –B : 50 Marks Viva –Voice : 20 Marks Total : 100 Marks

ENERGY CONVERSION LAB

V Semester

Subject Code	18MEL58	CIE Marks	40
Number of Lecture Hours/Week	02+02	SEE Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

Credits – 02

Course Objectives:

- This course will provide a basic understanding of fuel properties and its measurements using various types of measuring devices
- Energy conversion principles, analysis and understanding of I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
- Exhaust emissions of I C Engines will be measured and compared with the standards.

PART A

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus.
3. Determination of Calorific value of solid, liquid and gaseous fuels.
4. Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
5. Valve Timing/port opening diagram of an I.C. Engine.

PART B

1. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiency, Volumetric efficiency, Mechanical efficiency, SFC, FP, A:F Ratio, heat balance sheet for
    a. Four stroke Diesel Engine
    b. Four stroke Petrol Engine
    c. Multi Cylinder Diesel/Petrol Engine, (Morse test)
    d. Two stroke Petrol Engine
    e. Variable Compression Ratio I.C. Engine.
2. Measurements of Exhaust Emissions of Petrol engine.
3. Measurements of Exhaust Emissions of Diesel engine.

PART C (Optional)

1. Visit to Automobile Industry/service stations.
2. Demonstration of $p\theta$, pV plots using Computerized IC engine test rig

Course outcomes:

- Perform experiments to determine the properties of fuels and oils.
- Conduct experiments on engines and draw characteristics.
- Test basic performance parameters of I.C. Engine and implement the knowledge in industry.
- Identify exhaust emission, factors affecting them and exhibit his competency towards preventive maintenance of IC engines.

Reading:

1. E.F.Obert, Internal combustion engines and air pollution intext educational publishers (1973). John Heywood, Internal combustion engine fundamentals, McGraw- Hill (1988) - USA.
2. Colin R Ferguson and Allan T. Kirkpatrick Internal combustion engines Applied Thermodynamics, John Wiley & sons – 2001.
3. Richard stone, Introduction to internal combustion engines, MacMillan (1992) – USA
4. M. L. Mathur and R.P. Sharma A course in internal combustion engines, Dhanpat Rai& sons-India.
5. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
6. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003
7. Bosch, Automotive hand book, 9th edition.

Scheme of Examination:

ONE question from part A:		30 Marks
ONE question from part B:		50 Marks
Viva –Voice	:	20 Marks
Total	:	100 Marks

VI SEMESTER MECHANICAL 2018 SCHEME

FINITE ELEMENT METHODS
VI Semester

Course Code	18ME61	CIE Marks	40
Number of Hours/Week	3L+2T	SEE Marks	60
Total Number of Hours	70	Exam Hours	03
No. of Credits: 4			

Course Objectives:

- To learn the basic principles of finite element analysis procedure
- To understand the design and heat transfer problems with application of FEM.
- Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Module 1

Introduction to Finite Element Method: General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method.
Boundary conditions: homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain- displacement relations, Stress-strain relations, Plain stress and Plain strain conditions, temperature effects.
Interpolation models: Simplex, complex and multiplex elements, linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

10 Hours

Module 2

Introduction to the stiffness (Displacement) method: Introduction, Derivation of stiffness matrix, Derivation of stiffness matrix for a spring element, Assembly the total stiffness matrix by superposition. One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of localcoordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, , , Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 3 8), 2D isoparametric element, Lagrange interpolation functions.
Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Force terms: Body force, traction force and point loads, Numerical Problems:Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.

10 Hours

Module 3

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.
Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

10 Hours

Module 4

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, 1D finite element formulation using vibration method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.
Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.
10 Hours

Module 5

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.
Dynamic Considerations: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

10 Hours

Course outcomes:

Upon successful completion of this course you should be able to:

- Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.
- Develop element characteristic equation and generation of global equation.
- Formulate and solve Axi-symmetric and heat transfer problems.
- Apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi-symmetric and dynamic problems.

Text Books:

1. Logan, D. L., A first course in the Finite Element Method, 6th Edition, Cengage Learning, 2016.
2. Rao, S. S., Finite Element Method in Engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in Engineering, 2nd Edition, PHI, 2013.

Reference Books:

1. J.N.Reddy, “Finite Element Method”- McGraw -Hill International Edition.
2. Bathe K. J. Finite Elements Procedures, PHI.
3. Cook R. D., et al. “Concepts and Application of Finite Elements Analysis”- 4th Edition, Wiley & Sons, 2003.

E- Learning

• VTU, E- learning

DESIGN OF MACHINE ELEMENTS II
SEMESTER – VI

Subject Code	18ME62	CIE Marks	40
Hours/Week	(3L+2T)	SEE Marks	60
Total Hours	70	Exam Hours	03
No. of Credits: 4			

Course Objectives:

CLO1	To understand various elements involved in a mechanical system.
CLO2	To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards.
CLO3	To select transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue.
CLO4	To design a mechanical system integrating machine elements.
CLO5	To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes.

Content	No. of Hours/RBT levels
MODULE 1 **Springs:** Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads. Leaf Springs: Stresses in leaf springs, equalized stresses, and nipping of leaf springs. Introduction to torsion and Belleville springs. **Belts:** Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition. Selection of flat and V belts- length & cross section from manufacturers' catalogues. Construction and application of timing belts. **Wire ropes:** Construction of wire ropes, stresses in wire ropes, and selection of wire ropes.	**10 Hours** **L1, L2, L3, L4**
MODULE 2 **Gear drives:** Classification of gears, materials for gears, standard systems of gear tooth, lubrication of gears, and gear tooth failure modes. **Spur Gears:** Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear. **Helical Gears**: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.	**10 Hours** **L1, L2, L3, L4**

MODULE 3 **Bevel Gears:** Definitions, formative number of teeth, design based on strength, dynamic load and wear. **Worm Gears:** Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.	**10 Hours** **L1, L2, L3, L4**
MODULE 4 **Design of Clutches:** Necessity of a clutch in an automobile, types of clutch, friction materials and its properties. Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories. **Design of Brakes:** Different types of brakes, Concept of self-energizing and self-locking of brakes. Practical examples, Design of band brakes, block brakes and internal expanding brakes.	**10 Hours** **L1, L2, L3, L4**
MODULE 5 **Lubrication and Bearings:** Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. Numerical examples on hydrodynamic journal and thrust bearing design. **Antifriction bearings:** Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep grove ball bearings from the manufacturers' catalogue; selection of bearings subjected to cyclic loads and speeds; probability of survival.	**10 Hours** **L1, L2, L3, L4**

Assignment:

Course work includes a **Design project**. Design project should enable the students to design a mechanical system (like single stage reduction gear box with spur gears, single stage worm reduction gear box, V-belt and pulley drive system, machine tool spindle with bearing mounting, C-clamp, screw jack, etc.) A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Design project should be given due credit in internal assessment.

Course Outcomes:

After learning the course the students should be able to:

CO1	Apply design principles for the design of mechanical systems involving springs, belts, pulleys, and wire ropes.
CO2	Design different types of gears and simple gear boxes for relevant applications.

CO3	Understand the design principles of brakes and clutches.
CO4	Apply design concepts of hydrodynamic bearings for different applications and select Anti friction bearings for different applications using the manufacturers, catalogue.
CO5	Apply engineering design tools to product design.
CO6	Become good design engineers through learning the art of working in a team.

Textbooks:

[1] Richard G. Budynas, and J. Keith Nisbett, **"**Shigley's Mechanical Engineering Design**",** McGraw-Hill Education, 10th Edition, 2015.

[2] Juvinall R.C, and Marshek K.M, "Fundamentals of Machine Component Design", John Wiley & Sons, Third Edition, Wiley student edition, 2007.

[3] V. B. Bhandari, *"*Design of Machine Elements*"*, 4th Ed., Tata Mcgraw Hill, 2016.

References:

[1] Robert L. Norton "Machine Design- an integrated approach", Pearson Education, 2nd edition.

[2] Spotts M.F., Shoup T.E "Design and Machine Elements", Pearson Education, 8th edition, 2006.

[3] Hall, Holowenko, Laughlin (Schaum's Outline Series), "Machine design" adapted by S.K.Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

[4] H.G.Patil, S.C.Pilli, R.R.Malagi, M.S.Patil., "Elements of Machine Design", IK International, First edition,2019.

[5] T. Krishna Rao, Design of Machine Elements, Volume II, 2013,IK international publishing house, New Delhi.

[6], G. M. Maithra and L.V.Prasad, "Hand book of Mechanical Design", Tata McGraw Hill, 2nd edition,2004.

Design Data Hand Books:

[1] Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.

[2] Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.

[3] Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010

[4] PSG Design Data Hand Book, PSG College of technology, Coimbatore.

HEAT TRANSFER
VI Semester

Subject Code	18ME63	CIE Marks	40
Number of Hours/Week	03L+2T	SEE Marks	60
Total Number of Hours	70	Exam Hours	03
No. of Credits: 4			

Course Objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module 1 **10 Hours**

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Types of boundary conditions. General three dimensional Heat Conduction Equation: Derivation of the equation in (i) Cartesian, coordinate only. Discussion of three dimensional Heat Conduction Equation in (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) without heat generation and (ii) constant thermal conductivity - in Cartesian system with various possible boundary conditions. Brief Introduction to variable thermal conductivity and heat generation [No numerical on variable thermal conductivity and heat generation] Thermal Resistances in Series and in Parallel. Critical Thickness of Insulation in cylinder and spheres Concept. Derivation

Module 2 **10 Hours**

Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts.

Module 3 **10 Hours**

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction and one dimensional unsteady conduction, boundary conditions, solution methods.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's displacement law, Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange between parallel plates, concentric cylinders, and concentric spheres, Radiation Shield.

Module 4 **10 Hours**

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Turbulent flow, Various empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions.

Module 5	10 Hours

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts.

Introduction to boiling, pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation.

Course outcomes:

- Understand the modes of heat transfer and apply the basic laws to formulate engineering systems.
- Understand and apply the basic laws of heat transfer to extended surface, composite material and unsteady state heat transfer problems.
- Analyze heat conduction through numerical methods and apply the fundamental principle to solve radiation heat transfer problems.
- Analyze heat transfer due to free and forced convective heat transfer.
- Understand the design and performance analysis of heat exchangers and their practical applications, Condensation and Boiling phenomena.

TEXT BOOKS:

1. Principals of heat transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn, Seventh Edition, Cengage learning, 2011.

2. Yunus A. Cengel - Heat transfer, a practical approach, Fifth edition,Tata Mc Graw Hill.

REFERENCE BOOKS

1. Heat and mass transfer, Kurt C, Rolle, second edition, Cengage learning.

2. Heat Transfer, M. Necati Ozisik, A Basic Approach, McGraw Hill, New York, 2005.

3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., 5th Edition, John Wiley and Sons, New York, 2006.

4. Heat Transfer, Holman, J. P., 9th Edition, Tata McGraw Hill, New York, 2008.

PROFESSIONAL ELECTIVE 1

NON -TRADITIONAL MACHINING

VI SEMESTER

Subject Code	**18ME641**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits:03			

MODULE 1

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.

08 Hours

MODULE 2

Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.

Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

Water Jet Machining (WJM): Equipment & process, Operation, applications, advantages and limitations of WJM.

08 Hours

MODULE 3

ELECTROCHEMICAL MACHINING (ECM): Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

CHEMICAL MACHINING (CHM) Elements of the process: Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process. Process characteristics of CHM:

material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process. **8 Hours**

MODULE 4

ELECTRICAL DISCHARGE MACHINING (EDM) Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

PLASMA ARC MACHINING (PAM) Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations. **8 Hours**

MODULE 5

LASER BEAM MACHINING (LBM) Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations. ELECTRON BEAM MACHINING (EBM) Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations. **08 Hours**

Course Outcomes:

On completion of the course, the students will be able to:

1. Understand the compare traditional and non-traditional machining process and recognize the need for Non-traditional machining process.
2. Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.
3. Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.
4. Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.
5. Understand the LBM equipment, LBM parameters, and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

Text Books:

1. Modern Machining Process by P.C Pandey and H S Shah, McGraw Hill Education India Pvt. Ltd. 2000
2. Production technology, HMT, McGraw Hill Education India Pvt. Ltd. 2001

Reference Books:

1. New Technology, Dr. Amitabha Bhattacharyya, The Institute of Engineers (India), 2000
2. Modern Machining process, Aditya, 2002.

REFRIGERATION AND AIR CONDITIONING

V I SEMESTER

Subject Code	**18ME642**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits: 3			

Course learning objectives:

CLO1	Study the basic definition, ASHRAE Nomenclature for refrigerating systems.
CLO2	Understand the working principles and applications of different types of refrigeration systems.
CLO3	Study the working of air conditioning systems and their applications.
CLO4	Identify the performance parameters and their relations of an air conditioning system.

Module 1 **Introduction to Refrigeration** –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air. **Industrial Refrigeration**- Chemical and process industries, Dairy plants , Petroleum refineries, Food processing and food chain, Miscellaneous.	
Module 2 **Vapour Compression Refrigeration System(VCRS)**: Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle – liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling.	

Module 3 **Vapour Absorption Refrigeration Systems**: Absorbent – Refrigerant combinations, Water-Ammonia Systems, Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly. Practical problems – crystallization and air leakage, Commercial systems **Other types of Refrigeration systems**: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermoacoustic refrigeration systems	
Module 4 **Refrigerants:** Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropicmixtures **Refrigeration systems Equipment**: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.	
Module 5 **Air-Conditioning**: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems. **Transport air conditioning Systems**: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships.	

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Illustrate the principles, nomenclature and applications of refrigeration systems.
CO2	Explain vapour compression refrigeration system and identify methods for performance improvement
CO3	Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermoacoustic refrigeration systems.
C04	Estimate the performance of air-conditioning systems using the principles of psychrometry.
C05	Compute and Interpret cooling and heating loads in an air-conditioning system.
C06	Identify suitable refrigerant for various refrigerating systems.

TEXT BOOKS:

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2. Arora C.P., Refrigeration and Air-conditioning, Tata Mc Graw –Hill, New Delhi, 2nd Edition, 2001.
3. Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, Mc Graw - Hill, New Delhi 2nd edition, 1982.

REFERENCE BOOKS:

1. Dossat, Principles of Refrigeration Pearson-2006.
2. McQuistion, Heating, Ventilation and Air Conditioning, Wiley Students edition, 5^{th} edition 2000.
3. PITA, Air conditioning 4rth edition, pearson-2005
4. Refrigeration and Air-Conditioning' by Manohar prasad
5. S C Arora& S Domkundwar, Refrigeration and Air-Conditioning Dhanpat Rai Publication
6. http://nptel.ac.in/courses/112105128/#

Data Book:

1. Shan K. Wang, Handbook of Air Conditioning and Refrigeration, 2/e, 2001 McGraw-Hill Education
2. Mathur M.L. & Mehta ,Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, F.S., Jain Brothers,2008

E- Learning

- VTU, E- learning, MOOCS, Open courseware

Theory of Elasticity

VI semester

Subject Code	18ME643	CIE Marks	40
Number of Hours/Week	3L	SEE Marks	60
Total Number of Hours	40	Exam. Hours	03
Number of Credits: 3			

Content	Hours/ Blooms Level
Module I: Analysis of Stress: Definition and notation of stress, Equations of equilibrium in differential form, Stress components on an arbitrary plane, Equality of cross shear, Stress invariants, Principal stresses, Octahedral stress, Planes of maximum shear, Stress transformation, Plane state of stress, Mohr's diagram for 3 dimensional state of stress.	08Hrs L1, L2, L3
Module II: Analysis of Strain: Displacement field, Strains in term of displacement field, Infinitesimal strain at a point, Engineering shear strains, Strain invariants, Principal strains, Octahedral strains, Plane state of strain, Compatibility equations, Strain transformation. Principle of super position, Saint Venant principle.	08Hrs L1, L2, L3
Module III: Two-Dimensional classical elasticity: Cartesian co-ordinates, Relation between plane stress and plane strain, stress functions for plane stress and plane strain state, Airy's stress functions, investigation of Airy's stress function for simple beams. Bending of a narrow cantilever beam of rectangular cross section under edge load. Bending of simply supported beam under UDL, stress concentration, stress distribution in an infinite plate with a circular hole subjected to uniaxial and biaxial loads. General equations in polar coordinates, stress distribution symmetrical about an axis, Thick wall cylinder subjected to internal and external pressures.	10Hrs L2, L3
Module IV: Stress analysis in Axisymmetric body: Stresses in rotating discs of uniform thickness and cylinders. Numerical Problems. **Torsion:** Torsion of circular, elliptical and triangular bars, Prandtl's membrane analogy, Torsion of thin walled thin tubes, Torsion of thin walled multiple cell closed sections.	08Hrs L2, L3
Module V: Thermal stress: Thermo elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders.	06Hrs L2, L3
Text Books: 1. S. P. Timoshenko and J. N Gordier, "Theory of Elasticity", Mc-Graw Hill International, 3rd edition, 2010. 2. L. S. Srinath, "Advanced Mechanics of solids", Tata Mc. Graw Hill, 2009.	
Reference Books: 1. Sadhu Singh, "Theory of Elasticity", Khanna Publications, 2004. 2. T.G. Seetharamu and Govindaraju, "Applied Elasticity", Interline Publishing, 2008.	

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Understand the Basic field equations of linear elastic solids, force, stress, strain and equilibrium in solids.
CO2	Analyse the 2D structural elements, beams, cylinders.

CO3	Use analytical techniques to predict deformation, internal force and failure of simple solids and structural components.
CO4	Analyse the axisymmetric structural elements.
CO5	Analyse the structural members subjected to torsion
CO6	Determine the thermal stresses in plain stress and plane stain conditions.

ADVANCED VIBRATIONS
VI Semester

Course Code	18ME644	CIE Marks	40
Number of Hours/Week	3L	SEE Marks	60
Total Number of Hours	40	Exam Hours	03
No. of Credits: 03			

Course Objectives:

- To enable the students to understand the theoretical principles of vibration and vibration analysis techniques for the practical solution of vibration problems.
- To enable the students to understand the importance of vibrations in mechanical design of machine parts subject to vibrations
- To make free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi degree of freedom linear systems.
- Be able to write the differential equation of motion of vibratory systems,
- Be able to obtain linear and nonlinear vibratory models of dynamic systems with changing complexities

Module 1

Forced vibrations (1DOF): Introduction, analysis of forced vibration with constant harmonic excitation, MF, rotating and reciprocating unbalances, excitation of support (Relative and absolute amplitudes), force and motion transmissibility, energy dissipated due to damping and numerical problems.
Systems with 2DOF: Principal modes of vibrations, normal mode and natural frequencies of systems (Damping is not included), simple spring-mass systems, masses on tightly stretched strings, double pendulum, tensional systems, combined rectilinear and angular systems, geared systems and numerical problems.

08 Hours

Module 2

Numerical methods for multi DOF systems: Maxwell's reciprocal theorem, influence coefficients, Rayleigh's method, Dunkerley's method, stodola method, orthogonality principle, method of matrix iteration and numerical.
Modal analysis and condition monitoring: signal analysis, dynamic testing of machines and structures, experimental modal analysis, machine condition monitoring and diagnosis.

08 Hours

Module 3

Vibration measuring instruments and whirling of shafts: seismic instruments, vibrometers, accelerometer, frequency measuring instruments and numerical. Whirling of shafts with and without damping.
Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers and Vibration dampers.

08 Hours

Module 4

Transient Vibration of single Degree-of freedom systems: Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.
Random Vibrations: Random phenomena Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response.

08 Hours

Module 5

Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.
Continuous Systems: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.

08 Hours

Course outcomes:
At the end of the course students should be able to:

- Characterize the single and multi degrees of freedom systems subjected to free and forced vibrations with and without damping.
- Apply the method of vibration measurements and its controlling.
- Determine vibratory responses of SDOF and MDOF systems to harmonic, periodic and non-periodic excitation
- Analyze the mathematical model of a linear vibratory system to determine its response
- Obtain linear mathematical models of real life engineering systems
- Use the concept of dynamic vibrations for a continuous system.

TEXT BOOKS:

1. S. S. Rao, “Mechanical Vibrations”, Pearson Educ ation.
2. S. Graham Kelly, “Fundamentals of Mechanical Vib ration” - McGraw-Hill.
3. “Theory of Vibration with Application” - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education.
4. “Mechanical Vibrations”, V. P. Singh, Dhanpat Ra i & Company.
5. Mechanical Vibrations, W.T. Thomson W.T.- Prentice Hill India

REFERENCE BOOKS:

1. S. Graham Kelly, “Mechanical Vibrations”, Schaum ’s Outlines, Tata McGraw Hill.
2. C Sujatha, “Vibraitons and Acoustics – Measureme nts and signal analysis”, Tata McGraw Hill.
3. “Mechanical Vibrations”, G. K. Grover, Nem Chand and Bros.

E- Learning
• VTU, E- learning

COMPOSITE MATERIALS TECHNOLOGY

VI Semester

Course Code	18ME645	CIE Marks	40
Number of Hours/Week	3L	SEE Marks	60
Total Number of Hours	40	Exam Hours	03
No. of Credits: 3			

Course Objectives:

- To know the behaviour of constituents in the composite materials
- To Enlighten the students in different types of reinforcement
- To Enlighten the students in different types of matrices
- To develop the student's skills in understanding the different manufacturing methods available for composite material.
- To understand the various characterization techniques
- To illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

Module 1

Introduction to Composite Materials: Definition, classification & brief history of composite materials.
Constituent of composite materials: Reinforcements, Matrix, Coupling agents, coatings & fillers.
Reinforcements: Introduction, Glass Fibers, Boron Fibers, Carbon Fibers, Organic Fibers, Ceramic Fibers, Whiskers, Other Non-oxide Reinforcements, Comparison of Fibers
Matrix Materials: Polymers, Metals and Ceramic Matrix Materials.
Interfaces: Wettability, Crystallographic nature of interface, types of bonding at the interface and optimum interfacial bond strength.

08 Hours

Module 2

Polymer Matrix Composites (PMC): Processing of PMC's; Processing of Thermoset Matrix Composites, Thermoplastic Matrix Composites, Sheet Moulding Compound and carbon reinforced polymer composites. Interfaces in PMC's, Structure & Properties of PMC's, applications
Metal Matrix Composites: Types of metal matrix composites, Important Metallic Matrices, Processing, Interfaces in Metal Matrix Composites, Properties & Applications.

08 Hours

Module 3

Ceramic Matrix Composites (CMC): Processing of CMC's; Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation, In Situ Chemical Reaction Technique, Sol-Gel, Polymer Infiltration & Pyrolysis, Electrophoretic Deposition, Self-Propagating High Temperature Synthesis. Interfaces, properties and applications of CMC's.
Carbon Fiber/Carbon Matrix Composites: Processing of Carbon/Carbon Composites, Oxidation protection of Carbon/Carbon Composites, Properties of Carbon/Carbon Composites, and application of Carbon/Carbon Composites.

Multifilamentary Superconducting Composites: The Problem of Flux Pinning, Types of Super Conductor, Processing & structure of Multi filamentary superconducting composites. Applications of multifilamentary superconducting composites **08 Hours**

Module 4

Nonconventional Composites: Introduction, **Nanocomposites;** Polymer clay nanocomposites, self healing composites, self-reinforced composites. Biocomposites, **Laminates;** Ceramic Laminates, Hybrid Composites.

Performance/Characterization of Composites: Static Mechanical Properties; Tensile Properties, Compressive Properties, Flexural Properties, In-Plane Shear Properties, Interlaminar Shear Strength. **Fatigue Properties;** Tension–Tension Fatigue, Flexural Fatigue. **Impact Properties;** Charpy, Izod, and Drop-Weight Impact Test. **08 Hours**

Module 5

Micromechanics of Composites: Density, **Mechanical Properties;** Prediction of Elastic Constants, Micromechanical Approaches, Halpin-Tsai Equations, Transverse Stresses, Thermal properties. Numerical Problems.

Macromechanics of Composites: Introduction, Elastic constants of an isotropic material, elastic constants of a lamina, relationship between engineering constants and reduced stiffnesses and compliances.

08 Hours

Course Outcomes:

At the end of the course students should be able to:

- Use different types of manufacturing processes in the preparation of composite materials
- Analyze the problems on macro mechanical behaviour of composites
- Analyze the problems on micromechanical behaviour of Composites
- Determine stresses and strains relation in composites materials.
- Understand and effective use of properties in design of composite structures
- Perform literature search on a selected advanced material topic

TEXT BOOKS:

1. Composite Material Science and Engineering, Krishan K. Chawla, Springer, Third Edition, First Indian Reprint 2015.
2. Fibre-Reinforced Composites, Materials, Manufacturing, and Design, P.K. Mallick, Third Edition, CRC Press, Taylor & Francis Group.
3. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press,2004

REFERENCE BOOKS:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005
2. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009
3. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.

E- Learning

• VTU, E- learning

Computer Aided Modelling and Analysis Lab

SEMESTER – VI

Code	**15MEL66**	**CIE Marks**	**40**
Number of Hours / week	**2T+2L**	**SEE Marks**	**60**
Total Number of Hours	**02**	**Exam Hours**	**03**
No. of Credits: 2			

Course objectives:

- To acquire basic understanding of Modeling and Analysis software
- To understand the concepts of different kinds of loading on bars, trusses and beams, and analyze the results pertaining to various parameters like stresses and deformations.
- To lean to apply the basic principles to carry out dynamic analysis to know the natural frequencies of different kind of beams.

PART – A **Study of a FEA package and modeling and stress analysis of:** 1. Bars of constant cross section area, tapered cross section area and stepped bar 2. Trusses – (**Minimum 2 exercises of different types)** 3. Beams – Simply supported, cantilever, beams with point load , UDL, beams with varying load etc **(Minimum 6 exercises)** 4. Stress analysis of a rectangular plate with a circular hole	**24 Hours**
PART - B 1) Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions **(Minimum 4 exercises of different types)** **2)** Dynamic Analysis to find: a) Natural frequency of beam with fixed – fixed end condition b) Response of beam with fixed – fixed end conditions subjected to forcing function c) Response of Bar subjected to forcing functions	**24 Hours**
PART – C (only for demo) 1) Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver. 2) Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis. 3) Demonstrate at least two different types of example to model and analyze bars or plates made from composite material.	**08 Hours**

Course Outcomes:

At the end of the course, the students are able to:

- Use the modern tools to formulate the problem, create geometry, descritize, apply boundary conditions to solve problems of bars, truss, beams, and plate to find stresses with different-loading conditions.
- Demonstrate the ability to obtain deflection of beams subjected to point, uniformly distributed and varying loads and further to use the available results to draw shear force and bending moment diagrams.
- Analyze and solve 1D and 2D heat transfer conduction and convection problems with different boundary conditions.
- Carry out dynamic analysis and finding natural frequencies of beams, plates, and bars for various boundary conditions and also carry out dynamic analysis with forcing functions and analyze the results.

REFERENCE BOOKS:

1. A first course in the Finite element method, Daryl L Logan, Thomason, Third Edition

2. Fundaments of FEM, Hutton – McGraw Hill, 2004

3. Finite Element Analysis, George R. Buchanan, Schaum Series

Scheme for Examination:

One Question from Part A - 40 Marks

One Question from Part B - 40 Marks

Viva-Voce - 20 Marks

HEAT TRANSFER LAB

VI Semester

Subject Code	18MEL67	CIE Marks	40
Number of Hours/Week	2L+2T	SEE Marks	60
Total Number of Hours	56	Exam Hours	03
No. of Credits: 02			

Course Objectives:

- The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
- This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids, and vacuum.
- Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

PART A **24 Hours**

1. Determination of Thermal Conductivity of a Metal Rod.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in free Convection
5. Determination of Heat Transfer Coefficient in a Forced Convention
6. Determination of Emissivity of a Surface.

PART B **24 Hours**

1. Determination of Steffan Boltzmann Constant.
2. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
3. Experiments on Boiling of Liquid and Condensation of Vapour.
4. Performance Test on a Vapour Compression Refrigeration.
5. Performance Test on a Vapour Compression Air – Conditioner.
6. Experiment on Transient Conduction Heat Transfer.

PART C (Optional) **8 Hours**

1. Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).
2. Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)

Course outcomes:

- Determine the thermal conductivity of a metal rod and overall heat transfer coefficient of composite slabs.
- Determine convective heat transfer coefficient for free and forced convection and correlate with theoretical values.
- Evaluate temperature distribution characteristics of steady and transient heat conduction through solid cylinder experimentally.
- Determine surface emissivity of a test plate and Stefan Boltzmann constant
- Estimate performance of a refrigerator and effectiveness of a fin and Double pipe heat exchanger

Reading:

1. M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York, 2005.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, New York, 2006.
3. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

Scheme of Examination:

ONE question from part –A	:	40 Marks
ONE question from part –B	:	40 Marks
Viva –Voice	:	20 Marks
Total	:	100 Marks

OPEN ELECTIVE A
VI SEMESTER

NON-CONVENTIONAL ENERGY SOURCES Open Elective VI Semester			
Course Code	**18ME651**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**03**	**SEE Marks**	**60**
Total Number of Lecture Hours	**40**	**Exam Hours**	**03**
No. of Credits: 3			

Module 1	**8 Hours**
Introduction: Energy source, India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative). **Solar Radiation**: Extra-Terrestrial radiation, spectral distribution of extra terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. **Measurement of Solar Radiation:** Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.	
Module 2	**8 Hours**
Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. **Radiation Flux on a Tilted Surface:** Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical examples. **Solar Thermal Conversion:** Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems.	

Module 3	8 Hours
Performance Analysis of Liquid Flat Plate Collectors: General description, collector geometry, selective surface (qualitative discussion) basic energy-balance equation, stagnation temperature, transmissivity of the cover system, transmissivity – absorptivity product, numerical examples. The overall loss coefficient, correlation for the top loss coefficient, bottom and side loss coefficient, problems (all correlations to be provided). Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and collector flow factor, mean plate temperature, instantaneous efficiency (all expressions to be provided). Effect of various parameters on the collector performance; collector orientation, selective surface, fluid inlet temperature, number covers, dust. **Photovoltaic Conversion:** Description, principle of working and characteristics, applications	
Module 4	**8 Hours**
Wind Energy : Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples. **Tidal Power:** Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion:** Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.	
Module 5	**8 Hours**
Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **Energy from Bio Mass**: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages. **Hydrogen Energy**: Properties of Hydrogen with respected to its utilization as a renewable form of energy, sources of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production bio-chemical production.	

Course outcomes:

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

1. Describe the environmental aspects of non-conventional energy resources. In Comparison with various conventional energy systems, their prospects and limitations.
2. Know the need of renewable energy resources, historical and latest developments.
3. Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation, drying, cooking etc.
4. Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.

5. Understand the concept of Biomass energy resources and their classification, types of biogas Plants-applications
6. Compare Solar, Wind and bio energy systems, their prospects, Advantages and limitations.
7. Acquire the knowledge of fuel cells, wave power, tidal power and geothermal principles and applications.

TEXT BOOKS:

1. Non-Convention Energy Resources by B H Khan, McGraw Hill Education (India) Pvt. Ltd., 3rd Edition
2. Non-Conventional Energy Sources by *G.D Rai K*, Khanna Publishers, 2003.
3. Solar energy, by *Subhas P Sukhatme* – Tata McGraw Hill, 2nd Edition, 1996.

REFERENCE BOOKS

1. Renewable Energy Sources and Conversion Technology by *N.K.Bansal, Manfred Kleeman & Mechael Meliss*, Tata McGraw Hill.
2. Renewable Energy Resources, *John W.Twidell Anthony D. Weir El*,

WORLD CLASS MANUFACTURING

OPEN ELECTIVE

VI SEMESTER

Subject Code	18ME652	CIE Marks	40
Number of Lecture Hours/Week	03	SEE Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
No. of Credits: 3			

Content	No. of Hours/RBT levels
MODULE 1 Historical Perspective World class Excellent organizations – Models for manufacturing excellence: Schonberger, Halls, Gunn and Maskell models, Business Excellence.	**8 Hours** **L1, L2, L3**
MODULE 2 Benchmark, Bottlenecks and Best Practices, Concepts of benchmarking, Bottleneck and best practices, Best performers – Gaining competitive edge through world class manufacturing – Value added manufacturing – Value Stream mapping - Eliminating waste –Toyota Production System –Example.	**8 Hours** **L1, L2, L3**
MODULE 3 System and Tools for World Class Manufacturing. Improving Product & Process Design – Lean Production – SQC, FMS, Rapid Prototyping, Poka Yoke, 5-S ,3 M, JIT, Product Mix , Optimizing , Procurement & stores practices , Total Productive maintenance, Visual Control.	**10 Hours** **L1, L2, L3, L4**
MODULE 4 Human Resource Management in WCM: Adding value to the organization– Organizational learning – techniques of removing Root cause of problems–People as problem solvers–New organizational structures. Associates–Facilitators– Teamsmanship–Motivation and reward in the age of continuous improvement.	**8 Hours** **L1, L2, L3**
MODULE 5 Typical Characteristics of WCM Companies Performance indicators like POP, TOPP and AMBITE systems– what is world class Performance –Six Sigma philosophy. Indian Scenario on world class manufacturing –Task Ahead. Green Manufacturing, Clean manufacturing, Agile manufacturing.	**8 Hours** **L1, L2, L3, L4**

Course Outcomes:
After learning the course, the students should be able to:

CO1	Understand recent trends in manufacturing.
C02	Demonstrate the relevance and basics of World Class Manufacturing.
CO3	Understand customization of product for manufacturing.
CO4	Understand the implementation of new technologies.
CO5	Compare the existing industries with WCM industries.

Text Books:

1. Sahay B.S., Saxena KBC. and Ashish Kumar, World Class Manufacturing – Strategic Perspective, Mac Milan Publications, New Delhi.
2. Korgaonkar M.G., —Just In Time Manufacturing, MacMilan Publications.

References:

1. Adam and Ebert, —Production and Operational Management, 5th Edition, Prentice Hall learning pvt. Ltd., New Delhi.
2. Ron Moore, —Making Common Sense Common Practice – Models for manufacturingexcellence‖, Butter worth Heinmann
3. Jeffrey K.Liker, —The Toyota Way – 14 Management Principles‖, Mc-Graw Hill, 2003.
4. Chase Richard B., Jacob Robert., Operations Management for Competitive Advantage‖,11th Edition, McGraw Hill Publications, 2005.
5. Moore Ron, —Making Common Sense Common Practice‖, Butterworth-Heinemann, 2002.
6. World Class Manufacturing - The Lesson of Simplicity, Schonberger R. J, Free Press, 1986

SUPPLY CHAIN MANAGEMENT

OPEN ELECTIVE

VI SEMESTER

Subject Code	18ME653	CIE Marks	40
Number of Lecture Hours/Week	03	SEE Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
No. of Credits: 3			

Course Objectives:

CLO1	To acquaint with key drivers of supply chain performance and their inter-relationships with strategy.
CLO2	To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems.
CLO3	To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.

Content	No. of Hours/RBT levels
MODULE 1 Introduction: Supply Chain – Fundamentals –Evolution- Role in Economy - Importance - Decision Phases – Supplier Manufacturer-Customer chain. - Enablers/ Drivers of Supply Chain Performance. Supply chain strategy - Supply Chain Performance Measures.	**8 Hours** **L1, L2, L3**
MODULE 2 Strategic Sourcing Outsourcing – Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy - Supplier Selection and Contract Negotiation. Creating a world class supply base- Supplier Development - World Wide Sourcing.	**8 Hours** **L1, L2, L3**
MODULE 3 Warehouse Management Stores management-stores systems and procedures-incoming materials control-stores accounting and stock verification Obsolete, surplus and scrap-value analysis-material handling-transportation and traffic management -operational efficiency-productivity-cost effectiveness-performance measurement. Supply Chain Network Distribution Network Design – Role - Factors Influencing Options, Value Addition – Distribution Strategies - Models for Facility Location and Capacity allocation. Distribution Center Location Models.	**10 Hours** **L1, L2, L3, L4**

MODULE 4	8 Hours
Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design decisions using Decision trees. Planning Demand, -multiple item -multiple location inventory management. Pricing and Revenue Management.	L2, L3, L4
MODULE 5	**8 Hours**
Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain restructuring, Supply Chain Mapping - Supply Chain process restructuring, Postpone the point of differentiation – IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E- Business in supply chain.	**L1, L2, L3, L4**

Course Outcomes:

After learning the course, the students should be able to:

CO1	Understand the framework and scope of supply chain management.
CO2	Build and manage a competitive supply chain using strategies, models, techniques and information technology.
CO3	Plan the demand, inventory and supply and optimize supply chain network.
CO4	Understand the emerging trends and impact of IT on Supply chain.

TEXT BOOKS:

1. Janat Shah, Supply Chain Management – Text and Cases, Pearson Education, 2009.

2. Sunil Chopra and Peter Meindl, Supply Chain Management-Strategy Planning and Operation, PHI Learning / Pearson Education, 2007.

REFERENCES:

1. Ballou Ronald H, Business Logistics and Supply Chain Management, Pearson Education, 5 th Edition, 2007.
2. David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, Designing and Managing the Supply Chain: Concepts, Strategies, and Cases, Tata McGraw-Hill, 2005.
3. Altekar Rahul V, Supply Chain Management-Concept and Cases, PHI, 2005.
4. Shapiro Jeremy F, Modeling the Supply Chain, Thomson Learning, Second Reprint , 2002.
5. Joel D. Wisner, G. Keong Leong, Keah-Choon Tan, Principles of Supply Chain Management- A Balanced Approach, South-Western, Cengage Learning 2008.

ADVANCED MATERIALS TECHNOLOGY

OPEN ELECTIVE

VI SEMESTER

Subject Code	18ME654	CIE Marks	40
Number of Lecture Hours/Week	03	SEE Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
No. of Credits: 3			

Content	No. of Hours/RBT levels
MODULE 1 Classification and Selection of Materials: Classification of materials, properties required in Engineering materials, Selection of Materials; Motivation for selection, cost basis and service requirements - Selection for mechanical properties, strength, toughness, fatigue and creep - Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.	**8 Hours** **L1, L2, L3**
MODULE 2 Composite Materials: Fiber reinforced, laminated and dispersed materials with metallic matrix of aluminium, copper and Titanium alloys and with non-metallic matrix of unsaturated polyesters and epoxy resins. Development, Important properties and applications of these materials.	**8 Hours** **L1, L2, L3**
MODULE 3 Ceramics and Glasses - Bio-ceramics: Nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine. Low & High Temperature Materials: Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.	**10 Hours** **L1, L2, L3**
MODULE 4 Modern Metallic Materials: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides.	**8 Hours** **L1, L2, L3**

Non-metallic Materials: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers.	
MODULE 5 Smart Materials: Shape Memory Alloys, Varistors and Intelligent materials for bio-medical applications. Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.	**8 Hours** **L1, L2, L3, L4**

Course Outcomes:
After learning the course, the students should be able to:

CO1	Explain the concepts and principles of advanced materials and manufacturing processes.
CO2	Understand the applications of all kinds of Industrial materials.
CO3	Apply the material selection concepts to select a material for a given application.
CO4	Define Nanotechnology, Describe nano material characterization.
C05	Understand the behavior and applications of smart materials, ceramics, glasses and non-metallic materials.

REFERENCES:

1. Engineering Material Technology by James A. Jacobs & Thomas F. Kilduff. Prentice Hall.

2. Materials Science and Engineering by WD. Callister Jr., Wiley India Pvt. Ltd., 2010

3. Engineering Design: A Materials and Processing Approach by G.E. Dieter, McGraw Hill, 1991.

4. Materials Selection in Mechanical Design by M.F. Ashby, Pergamon Press, 1992.

5. Introduction to Engineering Materials & Manufacturing Processes by NIIT, Prentice Hall of India.

6. Engineering Materials Properties and Selection by Kenneth G. Budinski, Prentice Hall of India.

7. Selection of Engineering Materials by Gladius Lewis, Prentice-Hall, New Jersey, US.

VII SEMESTER MECHANICAL 2018 SCHEME

Control Engineering

VII Semester

Subject Code	**18ME71**	**CIE Marks**	**40**
Number of Hours/Week	**3L**	**SEE Marks**	**60**
Total Number of Hours	**3**	**Exam. Hours**	**03**
Number of Credits: 3			

Course Outcomes: The student on completion of the course will be able to:

CO1	Identify the type of control and control actions.
CO2	Develop the mathematical model of the physical systems.
CO3	Estimate the response and error in response of first and second order systems subjected standard input signals.
CO4	Represent the complex physical system using block diagram and signal flow graph and obtain transfer function.
CO5	Analyse a linear feedback control system for stability using Hurwitz criterion, Routh's criterion and root Locus technique in complex domain.
CO6	Analyse the stability of linear feedback control systems in frequency domain using polar plots, Nyquist and Bode plots.

Content	**Hours/ Blooms Level**
Module I:Introduction: Components of a control system, Open loop and closed loop systems. **Types of controllers:** Proportional, Integral, Differential, Proportional-Integral, and Proportional- Integral-Differential controllers. **Modeling of Physical Systems :** Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic Systems.	10Hrs L1,L2,L3

Module II: Time domain performance of control systems: Typical test signal , Unit step response and time domain specifications of first order, second order system. steady state error, error constants.	06Hrs L1,L2
Module III: Block diagram algebra, Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graphs, State diagram from differential equations.	08Hrs L2,L3
Module IV: Stability of linear control systems: Rouths criterion, Root locus, Determination of phase margin and gain margin using root locus	08Hrs L2,L3
Module V: Frequency domain analysis: Stability analysis using Polar plot, Nyquist plot, Bode plot, Determination of phase margin and gain margin using Bode plot.	08Hrs. L2,L3

Text Books:

1. Farid G., Kuo B. C., Automatic Control Systems, McGraw Hill Education, 10th Edition,2018
2. Manik D. N., Control systems, Cengage, 2017,

Reference Books:

1. K. Ogeta, Modern control Engineering, Pearson, 5th Edition, 2010.
2. Norman S Nice, Control Systems Engineering, Fourth Edition, Wiley Student Edition,2007.

Computer Integrated Design and Manufacturing

VII SEMESTER

Subject Code	18ME72	CIE Marks	40
Hours /Week	03	SEE Marks	60
Total Hours	40	Exam Hours	03
No. Of Credits: 3			

Course Objectives:

CLO1	To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
CLO2	To make students to understand the Computer Applications in Design and Manufacturing [CAD / CAM) leading to Computer integrated systems. Enable them to perform various transformations of entities on display devices.
CLO3	To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.
CLO4	To expose students to computer aided process planning, material requirement planning, capacity planning etc.
CLO5	To expose the students to CNC Machine Tools, CNC part programming, and industrial robots.
CLO6	To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to CIM and Automation:** Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM. Mathematical models and	**8 Hours** **L1, L2, L3**

matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in- process, numerical problems. **Automated Production Lines and Assembly Systems:** Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with storage buffer, fundamentals of automated assembly systems, numerical problems.	
Module 2 **CAD and Computer Graphics Software:** The design process, applications of computers in design**,** software configuration, functions of graphics package, constructing the geometry. Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations. **Computerized Manufacture Planning and Control System:** Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control.	**8 Hours** **L2, L3, L4**
Module 3 **Flexible Manufacturing Systems:** Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture. **Line Balancing:** Line balancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line balancing, computerized line balancing methods.	**8 Hours** **L1, L2, L3,L4**

Module 4. **Computer Numerical Control:** Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations. **Robot Technology:** Robot anatomy, joints and links, common robot configurations, robot control systems, accuracy and repeatability, end effectors, sensors in robotics. Robot programming methods: on-line and off-line methods. Robot industrial applications: material handling, processing and assembly and inspection.	**8 Hours** **L2, L3,L4**
Module 5 **Additive Manufacturing Systems:** Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM. **Future of Automated Factory:** Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, supply chain optimization, supply-chain & logistics, cyber-physical manufacturing systems.	**8 Hours** **L2, L3,L4**

Course Outcomes:

After studying this course, students will be able to:

CO1	Define Automation, CIM, CAD, CAM and explain the differences between these concepts. Solve simple problems of transformations of entities on computer screen.
CO2	Explain the basics of automated manufacturing industries through mathematical models and analyze different types of automated flow lines.
CO3	Analyze the automated flow lines to reduce down time and enhance productivity.

CO4	Explain the use of different computer applications in manufacturing, and able to prepare part programs for simple jobs on CNC machine tools and robot programming.
CO5	Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

TEXT BOOKS:

1. Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition, 2015, Pearson Learning.
2. CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.
3. CAD/CAM/CIM, Dr. P. Radhakrishnan, 3rd edition, New Age International Publishers, New Delhi.

REFERENCE BOOKS:

1. "CAD/CAM" by Ibrahim Zeid, Tata McGraw Hill.
2. "Principles of Computer Integrated Manufacturing", S.Kant Vajpayee, 1999, Prentice Hall of India, New Delhi.
3. "Work Systems And The Methods, Measurement And Management of Work", Groover M. P.,Pearson/Prentice Hall, Upper Saddle River, NJ, 2007.
4. "Computer Automation in Manufacturing", Boucher, T. O., Chapman & Hall, London, UK, 1996.
5. "Introduction to Robotics: Mechanics And Control", Craig, J. J., 2nd Ed., Addison-Wesley Publishing Company, Readong, MA, 1989.
6. Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition, by Nicolas Windpassinger, Amazon.
7. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker
9. "Understanding Additive Manufacturing", Andreas Gebhardt, Hanser Publishers, 2011
10. Industry 4.0: The Industrial Internet of Things, Apress, 2017, by Alasdair Gilchrist

PROFESSIONAL ELECTIVE 2

Design for Manufacture

SEMESTER – VII

Subject Code	**18ME731**	**CIE Marks**	**40**
Hours / Week	**03**	**SEE Marks**	**60**
Total Hours	**42**	**Exam Hours**	**03**
No. of Credits: 03			

Course objectives:

CLO1	To educate students on factors to be considered in designing parts and components with focus on manufacturability.
CLO2	To expose the students to dimensional tolerances, geometric tolerances and true position tolerance techniques in manufacture.
CLO3	To impart the knowledge on design considerations for designing components produced using various machining operations like turning, drilling, milling, grinding etc.
CLO4	To educate the students on design rules and recommendations for processes like casting, welding, forgings powder metallurgy and injection moulding.

Content	No. of Hours/RBT levels
Module 1 Major phases of design, effect of material properties on design, effect of manufacturing processes on design. Material selection process- cost per unit property, weighted properties and limits on properties methods. Guidelines for design for manufacturability. Review of relationship between attainable tolerance grades and different machining processes. Geometrical tolerances. Process capability, mean, variance, skewness, kurtosis, process capability indices- C_p, and C_{pk}. Cumulative effect of tolerance- Sure fit law and truncated normal law, problems.	**8 Hours** **L1, L2, L3**
Module 2 **Selective Assembly:** Interchangeable part manufacture and selective assembly. Deciding the number of groups -model-1: group tolerance of mating parts equal, model- 2: total and group tolerances of shaft equal. Control of axial play- introducing secondary machining operations, and laminated shims; examples. **True positional theory:** Comparison between coordinate and true position method of feature location. True position tolerance- virtual size concept, floating and fixed fasteners, projected tolerance zone and functional gages. Concept of Zero true position tolerance. Simple problems on true position tolerancing.	**8 Hours** **L2, L3, L4**
Module 3 **Datum Features:** Functional datum, datum for manufacturing, changing the datum; examples. **Component Design:** Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility. Design for assembly.	**8 Hours** **L2, L3, L4**

Module 4	8 Hours
Design of components with casting considerations: Pattern, mould, and parting line. Cored holes and machined holes. Identifying the possible and probable parting lines. Castings requiring special sand cores. Designing to obviate sand cores. **Welding considerations:** requirements and rules, redesign of components for welding; case studies.	**L2, L3, L4**
Module 5	**8 Hours**
Forging considerations -requirements and rules-redesign of components for forging and case studies. **Design of components for powder metallurgy**- requirements and rules-case studies. **Design of components for injection moulding**- requirements and rules-case studies.	**L2, L3, L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	**Select** proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic production.
CO2	**Identify** faulty design factors leading to increased costs in producing mechanical components.
CO3	**Apply** appropriate design tolerances – dimensional, geometric and true position tolerances for the production processes of mechanical components.
CO4	**Apply** the concepts related to reducing machined areas, simplification by amalgamation and separation, clampability, accessibility etc., in the design of mechanical components.
C05	**Analyse** the design of castings, weldments, forgings, powder metallurgy components and suggest design modifications to reduce the cost.

TEXTBOOKS:

1. Peck, H. “Designing for Manufacture”, Pitman Publications, London, 1983.
2. Dieter, G.E. “Engineering Design: A Materials and processing Approach”, McGraw Hill Co.Ltd, 2000.
3. Bralla, James G., “Handbook of Products Design for Manufacturing: A Practical Guide to Low-cost Production”, McGraw Hill, New York, 1986.

REFERENCES:

1. Eggert, R.J. “Engineering Design” Pearson Education, Inc., New Jersey, 2005.
2. Matousek , R. “Engineering Design”, Blackie and Son Limited, Glasgow, 1967.
3. Kalandar Saheb, S.D and Prabhakar, O. “Engineering Design for Manufacture”, ISPE 1999.
4. Trucks, H.E., “Design for Economical Production”, 2nd ed., Mich., Dearborn, SME 1987.
5. Linberg, Roy A., “Processes and Materials of Manufacture”, 4th ed., Allyn and Bacon, Boston, U.S.A., 1990.

AUTOMATION & ROBOTICS

VII SEMESTER

Subject Code	**18ME732**	**CIE Marks**	**40**
Number of Hours/Week	**3**	**SEE Marks**	**60**
Total Number of Hours	**40**	**Exam Hours**	**3**
No. of Credits: 3			

Course Objectives: This course provides

1) To identify potential areas for automation and justify need for automation.
2) To select suitable major control components required to automate a process or an activity
3) To study the various parts of robots and fields of robotics.
4) To study the various kinematics and inverse kinematics of robots.
5) To study the control of robots for some specific applications.

MODULE 1: Introduction to automation **8 hours**

Basic elements of an automated system, advanced automation functions, levels of automation, process industries versus discrete manufacturing industries, continuous versus discrete control, computer process control. Hardware components for automation and process control, sensors, actuators, analog to digital converters, digital to analog converters, input/output devices for discrete data

MODULE 2: Automated production lines **8 hours**

Fundamentals of automated production lines, application of automated production lines, analysis of transfer lines, automated assembly systems, fundamentals of automated assembly systems, quantitative analysis of assembly systems, automatic identification methods, barcode technology, radio frequency identification, other AIDC technologies

MODULE 3: Industrial Robotics **8 hours**

Robotic configuration, robot anatomy and related attributes, robot control systems, end effectors, sensors in robotics, industrial robot applications, robot accuracy and repeatability, different types of robots, various generations of robots, degrees of freedom – Asimov's laws of robotics, dynamic stabilization of robots.

MODULE 4: Spatial descriptions and transformations **8 hours**

Positions, orientations, and frames. Mappings: Changing descriptions from frame to frame. Operators: translations, rotations and transformations, transformation arithmetic transform equations, transformation of free vectors computational considerations, manipulator Kinematics, link description, link-connection description, actuator space joint space and Cartesian space

MODULE 5: Robot programming **8 hours**

Introduction, levels of robot programming, requirements of robot programming language, problems pertaining to robot programming languages, offline programming systems, central issues in OLP systems, automating subtasks in OLP systems, simple programs on robot applications

Course Outcomes: The student shall be able to

1) Translate and simulate a real time activity using modern tools and discuss the benefits of automation.
2) Identify suitable automation hardware for the given application.
3) Recommend appropriate modelling and simulation tool for the given manufacturing application.
4) Explain the basic principles of Robotic technology, configurations, control and programming of Robots.
5) Explain the basic principles of programming and apply it for typical Pick & place, loading & unloading and palletizing applications.

TEXT BOOKS:

1) Automation, Production systems, and computer integrated manufacturing-Mikell P. Groover 3rd edition, Pearson 2009
2) Introduction to robotics mechanics and control- John J. Craig 3rd edition, Pearson 2009

REFERENCE BOOKS:

1) Robotics for Engineers –Yoram Koren, McGraw Hill International, 1st edition, 1985.
2) Industrial Robotics-Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.
3) Robotic Engineering - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.
4) Computer Based Industrial Control- Krishna Kant, EEE-PHI,2nd edition,2010.
5) An Introduction to Automated Process Planning Systems- Tiess Chiu Chang & Richard A. Wysk.

COMPUTATIONAL FLUID DYNAMICS
VII SEMESTER

Subject Code	**18ME733**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits: 3			

Pre-requisites: Fluid Mechanics, Vector Calculus, Linear Algebra.

Course learning objectives:

- Study the governing equations of fluid dynamics
- Learn how to formulate and solve Euler's equation of motion.
- Become skilled at Representation of Functions on Computer
- Solve computational problems related to fluid flows

Module 1

Introduction to CFD and Governing Equations

Need of CFD as tool, role in R&D, continuum, material or substantial derivative or total derivative, gradient, divergence and curl operators, Linearity, Principle of Superposition. Derivation of Navier-Stokes equations in control volume (integral form) and partial differential form, Euler equations (governing inviscid equations). Mathematical classification of PDE (Hyperbolic, Parabolic, Elliptic). Method of characteristics, Introduction to Riemann Problem and Solution Techniques.

9 Hours

Module 2

One-dimensional Euler's equation

Conservative, Non conservative form and primitive variable forms of Governing equations. Flux Jacobian, Is there a systematic way to diagonalise '**A**'. Eigenvalues and Eigenvectors of Flux Jacobian. Decoupling of Governing equations, introduction of characteristic variables. Relation between the two non-conservative forms. Conditions for genuinely nonlinear characteristics of the flux Jacobian.

Introduction to Turbulence Modeling: Derivation of RANS equations and k-epsilon model.

8 Hours

Module 3

Representation of Functions on Computer

Need for representation of functions, Box Function, Hat Function, Representation of sinx using hat functions: Aliasing, high frequency, low frequency. Representation error as a global error. Derivatives of hat functions, Haar functions, Machine Epsilon. Using Taylor series for representation of Derivatives.

7 **Hours**

Module 4

Finite difference method – Applied to Linear Convection equation, Laplace Equations, Convection Diffusion equations, Burgers equations, modified equations • Explicit methods and Implicit methods – as applied to applied to linear convection equation, Laplace equations, convection-diffusion equation◦ FTCS,FTFS,FTBS,CTCS ◦ Jacobi Method, Gauss-Siedel, Successive Over Relaxation Method, TDMA.• VonNaumann stability (linear stability) analysis. Upwind Method in Finite Difference method.

8 Hours

Module 5

Finite volume method

Finite volume method. Finding the flux at interface.

Central schemes - Lax-Friedrichs Method, Lax-Wendroff Method, Two-Step Lax-Wendroff Method and Mac Cormack Method

Upwind Method in Finite Volume methods - Flux Splitting Method Steger and Warming, vanLeer, Roe's Method and finding Roe's Averages.

8 **Hours**

Course Outcomes

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

- Understand mathematical characteristics of partial differential equations.
- Explain how to classify and computationally solve Euler and Navier-Stokes equations.
- Make use of the concepts like accuracy, stability, consistency of numerical methods for the governing equations.
- Identify and implement numerical techniques for space and time integration of partial differential equations.
- Conduct numerical experiments and carry out data analysis.
- Acquire basic skills on programming of numerical methods used to solve the Governing equations.

Text Books:

1. T.j.chung, Computational Fluid Dynamics, , Cambridge University Press
2. Ghoshdastidar, Computational fluid dynamics and heat transfer, Cengage learning, 2017.
3. Charles Hirsch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics – Vol 1 & Vol 2, Butterworth- Heinemann, 2007

Reference Books:

1. Pletcher, r. H., Tannehill, j. C., Anderson, d., Computational fluid mechanics and heat transfer, 3rd ed., Crc press, 2011, ISBN 9781591690375.
2. Moin, p., Fundamentals of engineering numerical analysis, 2nd ed., Cambridge university press, 2010, ISBN 9780521805261 (e- book available).
3. Ferziger, j. H., Numerical methods for engineering application, 2nd ed., Wiley, 1998.
4. Ferziger, j. H., Peric, m., Computational methods for fluid dynamics, 3rd ed., Springer, 2002.
5. Leveque, r., Numerical methods for conservation laws, lectures in mathematics, eth Zurich, birkhauser,199
6. Riemann Solvers and Numerical methods for Fluid Dynamics – A
7. Practical Introduction- Eleuterio F Toro, Springer Publications.

MOOCs:

1. Introduction to CFD by Prof M. Ramakrishna, Aerospace Engineering, IIT Madras.
2. Computational fluid dynamics by Prof Suman Chakraborty, Mechanical Engineering, IIT Kharagpur

E-Books:

1. Hirsch, c., Numerical computation of internal and external flows, 2nd ed., Butterworth-Heinemann, 2007, ISBN 9780750665940 (e-book available).

TOTAL QUALITY MANAGEMENT

VII Semester

Subject Code	**18ME734**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. of Credits:03			

COURSE LEARNING OBJECTIVES:

1. Understand various approaches to TQM

2. Understand the characteristics of quality leader and his role.

3. Develop feedback and suggestion systems for quality management.

4. Enhance the knowledge in Tools and Techniques of quality management.

Module 1

Principles and Practice: Definition, basic approach, gurus of TQM, TQMFramework, awareness, defining quality, historical review, obstacles, benefitsof TQM. Quality Management Systems: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.

08 Hours

Module 2

Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making,

08 Hours

Module 3

Customer Satisfaction and Customer Involvement: Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs intorequirements, customer retention,casestudies. Employee Involvement – Motivation, employee

surveys, empowerment,teams, suggestion system, recognition and reward, gain sharing, performanceappraisal, unions and employee involvement, case studies.

08 Hours

Module 4

Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies. Statistical Process Control : Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.

8 Hours

Module 5

Tools and Techniques: Benching marking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance.

08 Hours

COURSE OUTCOMES:

After studying this course, students will be able to:

1. Explain the various approaches of TQM
2. Infer the customer perception of quality
3. Analyze customer needs and perceptions to design feedback systems.
4. Apply statistical tools for continuous improvement of systems
5. Apply the tools and technique for effective implementation of TQM.

TEXT BOOKS:

1. Total Quality Management: Dale H. Besterfield, Publisher -Pearson Education India, ISBN: 8129702606, Edition 03.

2. Total Quality Management for Engineers: M. Zairi, ISBN:1855730243, Publisher: Wood head Publishing

REFERENCE BOOKS:

1. Managing for Quality and Performance Excellence by James R. Evans and William M Lindsay,9th edition, Publisher Cengage Learning.
2. A New American TQM, four revolutions in management, Shoji Shiba, Alan Graham, David Walden, Productivity press, Oregon, 1990
3. Organizational Excellence through TQM, H. Lal, New age Publications, 2008
4. Engineering Optimization Methods and Applications, A Ravindran, K, M. Ragsdell, Willey India Private Limited,2nd Edition,2006.
5. Introduction to Operations Research- Concepts and Cases, F.S. Hillier. G.J. Lieberman, 9th Edition, Tata McGraw Hill. 2010.

OPERATIONS RESEARCH

VII SEMESTER

Subject Code	**18ME735**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits:03			

Course objectives:

1. To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.

2. To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

MODULE 1

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

8 Hours

MODULE 2

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

8 Hours

MODULE 3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. Assignment Problem-Formulation, Solutions to

assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

10 Hours

MODULE 4

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems. Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.

8 Hours

MODULE 5

Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulation of games. Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method.

08 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Understand the meaning, definitions, scope, need, phases and techniques of operations research. 2. Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
3. Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
4. Solve problems on game theory for pure and mixed strategy under competitive environment.
5. Solve waiting line problems for M/M/1 and M/M/K queuing models.
6. Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.
7. Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3 machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm.

TEXT BOOKS:

1. Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD. Publications, New Delhi – 2007

2. Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006.

REFERENCE BOOKS:

1. Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt.Ltd. 2016.

2. Operations Research, Paneerselvan, PHI

3. Operations Research, A M Natarajan, P Balasubramani, PearsonEducation, 2005

4. Introduction to Operations Research, Hillier and Lieberman,8thEd., McGraw Hill

PROFESSIONAL ELECTIVE 3

ADDITIVE MANUFACTURING

VII Semester

Subject Code	**18ME741**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. of Credits: 3			

Course Objectives:

CLO1	To know the principle methods, areas of usage, possibilities and limitations of the Additive Manufacturing technologies.
CLO2	To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
CLO3	To know the principles of polymerization and powder metallurgy process, extrusion-based system printing processes, sheet lamination processes, beam deposition processes, direct write technologies and Direct Digital Manufacturing.
CLO4	To get exposed to process selection, software issues and post processing.

Content	No. of Hours/RBT levels
Module 1 **Introduction and basic principles:** Need for Additive Manufacturing, Generic AM process, stereolithography or 3d printing, rapid prototyping, the benefits of AM, distinction between AM and CNC machining, other related technologies-reverse engineering technology. **Development of Additive Manufacturing Technology:** Introduction, computers, computer-aided design technology, other associated technologies, the use of layers, classification of AM processes, metal systems, hybrid systems, milestones in AM development. **Additive Manufacturing Process chain:** Introduction, the eight steps in additive manufacture, variations from one AM machine to another, metal systems, maintenance of equipment, materials handling issues, design for AM, and application areas.	**8 Hours** **L1, L2, L3**
Module 2 **Photopolymerization processes:** Stereolithography (SL), Materials, SL resin curing process, Micro-stereolithography, Process Benefits and Drawbacks, Applications of Photopolymerization Processes. **Powder bed fusion processes:** Introduction, Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes. **Extrusion-based systems:** Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.	**8 Hours** **L1, L2, L3**
Module 3 **Printing Processes:** evolution of printing as an additive manufacturing process, research achievements in printing deposition, technical challenges of printing, printing process modeling, material modification methods, three-dimensional printing, advantages of binder printing **Sheet Lamination Processes:** Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.	**8 Hours** **L2, L3, L4**

Beam Deposition Processes: introduction, general beam deposition process, description material delivery, BD systems , process parameters, typical materials and microstructure, processing–structure–properties relationships, BD benefits and drawbacks. **Direct Write Technologies:** Background, ink-based DW, laser transfer, DW thermal spray, DW beam deposition, DW liquid-phase direct deposition.	
Module 4 **Guidelines for Process Selection:** Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control. **Software issues for Additive Manufacturing:** Introduction, preparation of cad models – the STL file, problems with STL files, STL file manipulation. **Post-Processing: S**upport material removal**,** surface texture improvements**,** preparation for use as a pattern, property enhancements using non-thermal techniques and thermal techniques**.**	**8 Hours** **L2, L3, L4**
Module 5 **The use of multiple materials in additive manufacturing:** Introduction, multiple material approaches, discrete multiple material processes, porous multiple material processes, blended multiple material processes, commercial applications using multiple materials, future directions. **AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application: Examples for Aerospace, defense, automobile, Bio-medical and general engineering industries. **Direct digital manufacturing**: Align Technology, siemens and phonak, DDM drivers, manufacturing vs. prototyping, life-cycle costing, future of direct digital manufacturing.	**8 Hours** **L2, L3, L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
CO2	Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
CO3	Understand the various software tools, processes and techniques that enable advanced/additive manufacturing.
CO4	Apply the concepts of additive manufacturing to design and create components that satisfy product development/prototyping requirements, using advanced/additive manufacturing devices and processes.
C05	Understand characterization techniques in additive manufacturing.
CO6	Understand the latest trends and business opportunities in additive manufacturing.

TEXT BOOK:

1. I. Gibson l D. W. Rosen l B. Stucker "**Additive Manufacturing Technologies** Rapid Prototyping to Direct Digital Manufacturing ISBN: 978-1-4419-1119-3 e-ISBN: 978-1-4419-1120-9 DOI 10.1007/978-1-4419-1120-9 Springer New York Heidelberg Dordrecht, London.

REFERENCE BOOKS:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
2. Ali K. Kamrani, EmandAbouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006.
3. D.T. Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer 2001.
4. RafiqNoorani, "Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley & Sons, 2006.
5. Hari Prasad, K S Badarinarayan, " Rapid Pototyping and Tooling" Published by SIP Pageturners, 2013.
6. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

EMERGING SUSTAINABLE BUILDING COOLING TECHNOLOGIES

VII Semester

Course Code	**18ME742**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**03L**	**SEE Marks**	**60**
Total Number of Lecture Hours	**40**	**Exam Hours**	**03**
No. of Credits: 3			

Module 1	**8 Hours**

Social and Environmental Issues related to conventional Refrigeration and Airconditioning:

Climate Change and energy poverty implications of energy consumption and refrigerants use by conventional Vapor-Compression based RAC technologies, Global and Indian environmental, energy efficiency and green building policies, laws and rules warranting a trajectory shift in the RAC economy, Introduction to Thermal comfort as an 'ends' and cooling systems as a 'means', Socio-economic and environmental benefits of a Negawatt approach to energy conservation vs. a Megawatt approach towards power generation.

Module 2	**8 Hours**

Thermal Comfort, Climate Analysis and Psychrometry:

The 'human thermal comfort' lens and its implications for cooling system design, Progressive models for addressing human thermal comfort needs, Thermodynamics of human body, Factors affecting human comfort, Introduction to the ASHRAE Std. 55 Adaptive Comfort Model and the Indian Model for Adaptive Comfort (IMAC) and its implications for mitigating climate change and energy consumption from cooling technologies, Tools for predicting thermal comfort in buildings, Principles and tools for climate analysis, Composition of Psychrometric Charts, Psychrometric processes of conventional and sustainable cooling technologies and representation on psychrometric chart, Application of psychrometry to design conventional and sustainable cooling technologies.

Indoor Air Quality and Building Cooling Load Modelling:

Addressing trade-offs between indoor air quality requirements, daylighting needs, and solar heat gain reduction in artificially cooled buildings, Factors affecting building cooling loads, Building cooling load software modelling (Practical Exercises).

Module 3 **8 Hours**

Refrigeration Systems and Refrigerants:

Thermodynamics of Vapor Compression Refrigeration (VCR) and Vapor Absorption Machine (VAM) Cycles, Equipment used in commercial and residential VCR and VAM systems, Physical, Chemical, Thermodynamic and Environmental properties of Refrigerants and Refrigerant mixtures **(**zeotropic and azeotropic mixtures) used in conventional VCR system, Absorbent **–** Refrigerant combinations (Water-Ammonia and Lithium- Bromide) used in VAM systems, Physical, Chemical, Thermodynamic and Environmental properties of emerging Natural Refrigerants for VCR systems

Module 4 **8 Hours**

Airconditioning:

Air-conditioning demand scenarios for India and associated health, social justice, energy access, and environmental Implications for its peoples and communities, Potential sustainable airconditioning scenarios for India, Heat transfer and psychrometric principles of airconditioning cycles, Engineering principles of airconditioning components, Airconditioning coefficient-of-performance calculation, Energy efficient airconditoning system, Energy and greenhouse gas emissions-based performance comparison of natural refrigerant and f-gas based airconditioners.

Module 5 **8 Hours**

Sustainable Cooling Technologies:

Radical social justice fostering, energy conservation, and climate change mitigation potential of natural cooling, Design principles of natural and sustainable cooling systems, Science and engineering design principles of a) Direct, Indirect, and Hybrid (Direct-Indirect and DX) Evaporative Cooling technology, b) Structure Cooling, c) Radiant Cooling Systems, and d) Solar VAM technology, Basic equipment sizing calculations, System performance assessment methods, Comparative energy consumption, greenhouse gas emissions and life-cycle cost case studies for residential and commercial applications of conventional and sustainable cooling technologies

Course outcomes:

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

1. Empathize with sustainable cooling as a means of enhancing social justice in India and mitigating climate change through their intellectual capabilities and ethical orientation
2. Compute and Interpret cooling and heating loads in a building and how they could be efficiently managed by using building energy modelling software.
3. Estimate the performance of airconditioning systems using the principles of thermodynamics, heat transfer, and psychometry.
4. Calculate and interpret the energy, cost, and greenhouse gas emissions performance of conventional and sustainable cooling technologies
5. Conduct building and sustainable cooling modelling projects on a sophisticated building energy modelling software.

TEXT BOOKS:

1. Refrigeration and Airconditioning" by C P Arora, Tata McGraw Hill, 3rd Edition.
2. Heating, Ventilating and Airconditioning by Faye C McQuiston, Jerald D. Parker, Jeffrey D. Spitler, Wiley Indian Private Ltd.

REFERENCE BOOKS

1. **"Radiant Heating and Cooling Handbook"** Author - Richard D. Watson; Published by - McGraw-Hill; Publication Year- 2002
   Link: https://www.accessengineeringlibrary.com/browse/radiant-heating-and-cooling-handbook#p2000a97e9970iii001
2. **"Evaporative Cooling"** Published by – CAREL
   Link: http://www.carel.com/-evaporative-cooling-book

FRACTURE MECHANICS

SEMESTER-VII

Subject Code	**18ME743**	**CIE Marks**	**40**
Hours / Week	**3L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. of Credits: 03			

Course Objectives:

CLO1	To expose the students to the fundamentals of mechanics of fracture of materials.
CLO2	The students will learn about stress / strain and deformation fields near a crack tip, fracture characterizing parameters like stress intensity factor and J integral and kinetics of fatigue crack growth.
CLO3	To expose the students to fundamentals of linear elastic fracture mechanics, nonlinear (Elastic-Plastic) fracture mechanics and fatigue crack growth.
CLO4	Exposure to experimental methods for determining the fracture toughness (for example, ASTM standard procedure for JIC testing).
CL05	To learn the mechanism of failure of structures by fatigue crack growth.

Content	**No. of Hours/RBT levels**
Module 1 **Fracture mechanics principles:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, and Griffith's energy balance approach. Fracture mechanics approach to design, NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress function. Effect of finite crack size. Elliptical cracks, Numerical problems.	**8 Hours** **L2, L3,L4**
Module 2 **Plasticity effects:** Irwin plastic zone correction. Dugdale's approach. The shape of the plastic zone for plane stress and plane strain cases. The plate thickness effect,	**8 Hours** **L2, L3, L4**

numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, estimation of stress intensity factors. Experimental method- Plane strain fracture toughness test, The Standard test, size requirements, etc.	
Module 3 **The energy release rate**, Criteria for crack growth. The crack resistance(R curve). Compliance. Tearing modulus. Stability. **Elastic plastic fracture mechanics:** Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD.	**8 Hours** **L2, L3, L4**
Module 4 J integral: Use of J integral. Limitation of J integral. Experimental determination of J integral and the parameters affecting J integral. Dynamics and crack arrest: Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.	**8 Hours** **L2, L3, L4**
Module 5 **Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, Paris law, Required information for fracture mechanics approach.	**8 Hours** **L2, L3, L4**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	**Analyse** the effects of crack like defects on the performance of Aerospace, Civil, and Mechanical Engineering structures.
CO2	**Apply** the concepts of fracture mechanics to select appropriate materials for engineering structures to insure damage tolerance.
CO3	**Understand** mechanics of crack tip fields and appropriate fracture characterizing parameters like stress intensity factor and J integral or nonlinear energy release rate and how to compute them using various methods.

CO4	**Apply** the concepts of fracture mechanics to determine critical crack sizes and fatigue crack propagation rates in engineering structures leading to life estimation.
C05	**Understand** the status of academic research in field of fracture mechanics.

TEXT BOOKS:

1. Prasanth Kumar, "Elements of fracture mechanics", Wheeter publication, 1999.

2. Anderson, Fracture Mechanics: Fundamentals and Applications, CRC press, 3rd Ed., 2005

REFERENCE BOOKS:

1. Karen Hellan , "Introduction to fracture mechanics", McGraw Hill, 2nd Edition

2. S.A. Meguid , "Engineering fracture mechanics" Elsevier Applied Science, 1989

3. Jayatilaka, "Fracture of Engineering Brittle Materials", Applied Science Publishers, 1979

4. Rolfe and Barsom , "Fracture and Fatigue Control in Structures" , Prentice Hall, 1977

5. Knott , "Fundamentals of fracture mechanisms", Butterworths, 1973

6. Broek, Engineering Fracture Mechanics, Martinus Nijhoff publishers, 1982.

7. M.F.Kanninen and C.H.Popelar, Advanced Fracture Mechanics, Oxford press, 1985.

MECHATRONICS
VII Semester

Course Code	18ME744	CIE Marks	40
Number of Hours/Week	3L	SEE Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
No. of Credits: 3			

Course objectives:

CLO1	To acquire a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
CLO2	To understand the evolution and development of Mechatronics as a discipline.
CLO3	To substantiate the need for interdisciplinary study in technology education
CLO4	To understand the applications of microprocessors in various systems and to know the functions of each element.
CL05	To demonstrate the integration philosophy in view of Mechatronics technology
CL06	To be able to work efficiently in multidisciplinary teams.

Content	No. of Hours/RBT levels
Module 1 **Introduction:** Definition, Multidisciplinary Scenario, Evolution of Mechatronics, Design of Mechatronics system, Objectives, advantages and disadvantages of Mechatronics. **Transducers and sensors:** Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, Potentiometers, LVDT, Capacitance sensors, force and pressure sensors, Strain gauges, temperature sensors, proximity switches and Hall Effect sensors.	**8 Hours** **L1, L2, L3**
Module 2 **Microprocessor & Microcontrollers:** Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers. Microprocessor Architecture: Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data, Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor.	**8 Hours** **L1, L2, L3,**
Module 3 **Programmable logic controller:** Introduction to PLC's, basic structure, Principle of operation, Programming and concept of ladder diagram, concept of latching & selection of a PLC. **Integration:** Introduction & background, Advanced actuators, Pneumatic actuators, Industrial Robot, different parts of a Robot-Controller, Drive, Arm, End Effectors, Sensor & Functional requirements of robot.	**8 Hours** **L1, L2, L3**
Module 4 Design of modern Computer Numerical Control (CNC) machines and mechatronics elements – Drives: DC, AC, brushless, servo and stepper motors- Construction – Working Principle – Advantages and Disadvantages. Machine structure: guide ways, Linear motion guides, Roller and ball screws. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing. Measuring system for NC machines: direct and indirect measuring system.	**8 Hours** **L1, L2, L3**

Module 5	8 Hours
Pneumatic and hydraulic actuation systems: Actuating systems, Pneumatic and hydraulic systems, Classifications of Valves, Pressure relief valves, Pressure regulating/reducing valves, Cylinders and rotary actuators, DCV & FCV- Principle & construction details, types of sliding spool valve, solenoid operated, Symbols of hydraulic elements, components of hydraulic system, functions of various units of hydraulic system. Design of simple hydraulic circuits for various applications. Design process-stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Automatic car park barrier.	**L2, L3, L4**

Course outcomes:
On completion of this subject, students will be able to:

CO1	Illustrate various components of Mechatronics systems.
CO2	Assess various control systems used in automation.
CO3	Develop mechanical, hydraulic, pneumatic and electrical control systems.
CO4	Design and conduct experiments to evaluate the performance of a mechatronics system or component with respect to specifications, as well as to analyze and interpret data.
C05	Function effectively as members of multidisciplinary teams.

TEXT BOOKS:

1. Nitaigour Premchand Mahalik , Mechatronics-Principles, Concepts and Applications, Tata McGraw Hill, 1stEdition, 2003 ISBN.No. 0071239243, 9780071239240.
2. W.Bolton-Pearson Education, Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering, 1stEdition, 2005 ISBN No. 81-7758-284-4.

REFERENCE BOOKS:

1. Mechatronics by HMT Ltd. – Tata McGrawHill, 1 st Edition, 2000. ISBN:9780074636435.
2. Anthony Esposito, Fluid Power, Pearson Education, 6th Edition, 2011, ISBN No.9789332518544.
3. K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram. Mechatronics: Integrated Mechanical Electronic Systems. Wiley India Pvt. Ltd., New Delhi 2008.

4. David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA 2003.
5. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi 2006.
6. Devdas Shetty, Richard A. kolk, Mechatronics System Design, second edition, Cengage publishers.

E- Learning: VTU, E- learning

PROJECT MANAGEMENT

VII SEMESTER

Subject Code	**18ME745**	**CIE Marks**	**40**
Hours / Week	**03L**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits:03			

MODULE 1

Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles Project Selection and Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects.

08 Hours

MODULE 2

Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system. Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart.

08 Hours

MODULE 3

Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control. Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kick off: Development of quality concepts, project quality management plan, project quality tools, kick off project, baseline and communicate project management plan, using Microsoft Project for project baselines.

08 Hours

MODULE 4

Performing Projects: Project supply chain management: - Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management. 28 Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge management, perform administrative and contract closure.

08 Hours

MODULE 5

Network Analysis Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERTfor finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

8 Hours

Course Outcomes:

On completion of the course, the student will be able to:

1. Understand the selection, prioritization and initiation of individual projects and strategic role of project management.

2. Understand the work breakdown structure by integrating it with organization.

3. Understand the scheduling and uncertainty in projects.

4. Students will be able to understand risk management planning using project quality tools.

5. Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.

6. Determine project progress and results through balanced scorecard approach

7. Draw the network diagram to calculate the duration of the project and reduce it using crashing.

TEXT BOOKS:

1. Project Management, Timothy J Kloppenborg, Cengage Learning, Edition 2009.

2. Project Management, A systems approach to planning scheduling and controlling by Harold kerzner, CBS publication.

3. Project Management by S Choudhury, Mc Graw Hill Education (India) Pvt. Ltd. New Delhi, 2016

REFERENCE BOOKS:

1. Project Management, Pennington Lawrence, Mc Graw hill

2. Project Management, A Moder Joseph and Phillips New Yark Van Nostrand, Reinhold.

3. Project Management,Bhavesh M. Patal, Vikas publishing House,

COMPTER INTEGRATED MAUFACTURING LAB

SEMESTER – VII

Subject Code	**18MEL76**	**CIE Marks**	**40**
Hours/Week	**02T + 02 P**	**SEE Marks**	**60**
Total Hours	**56**	**Exam Hours**	**03**
No. Of Credits: 2			

Course Objectives:

CLO1	To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes.
CLO2	To educate the students on the usage of CAM packages.
CLO3	To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics.

Content	**No. of Hours/RBT levels**
Part-A **Manual CNC part programming** using ISO Format G/M codes for 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path using CNC program verification software. **CNC part programming using CAM packages**. Simulation of Turning, Drilling, Milling operations. 3 typical simulations to be carried out using simulation packages like: **Cadem CAMLab-Pro, Master- CAM.** Program generation using software. Optimize spindle power, torque utilization, and cycle time. Generation and printing of shop documents like process and cycle time sheets, tool list, and tool layouts. Cut the part in single block and auto mode and measure the virtual part on screen. **Post processing of CNC programs** for standard CNC control systems like **FANUC, SINUMERIC and MISTUBISHI.**	**44 Hours** **L2, L3, L4**

Part B	12 Hours
(Only for Demo/Viva voce) **FMS (Flexible Manufacturing System)**: Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components. **(Only for Demo/Viva voce)** **Robot programming:** Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs). **Pneumatics and Hydraulics, Electro-Pneumatics:** 3 typical experiments on Basics of these topics to be conducted.	**L1, L2, L3**

Corse Outcomes:

After studying this course, students will be able to:

CLO1	**Understand** CNC Lathe part programming techniques for Turning, Facing, Chamfering, Grooving, Step turning, Taper turning, Circular interpolation etc.
CLO2	**Generate** CNC Mill Part programming for Point to point motions, Line motions, Circular interpolation, Contour motion, Pocket milling- circular, rectangular, Mirror commands etc.
CLO3	**Apply** Canned Cycles for Drilling, Peck drilling, Boring, Tapping, Turning, Facing, Taper turning Thread cutting etc.
CLO4	**Apply** simulation techniques for Tool Path generation for different machining operations of small components using CNC Lathe & CNC Milling Machine.
CLO5	**Apply** high end CAM packages for machining complex parts; use state of art cutting tools and related cutting parameters and optimize cycle time.
CLO6	**Understand** & write programs for Robot control; understand the operating principles of hydraulics, pneumatics and electro pneumatic systems.

Scheme for Examination:

Two Questions to be set; one question from manual part programming and one from part programming using CAM package. (25 marks each)
Viva-Voce - 10 Marks
Total: 60 Marks

Software Requirement: Cadem CAMLab-Pro, Master- CAM, and/or any other related software.

Design Laboratory
VII Semester

Subject Code	**18MEL77**	**CIE Marks**	**40**
Number of Hours/Week	**2T+2P**	**SEE Marks**	**60**
Total Number of Hours	**4**	**Exam. Hours**	**03**
Number of Credits: 2			

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Compute the natural frequency of the free and forced vibration of single degree freedom systems, critical speed of shafts.
CO2	Carry out balancing of rotating masses.
CO3	Analyse the governor characteristics.
CO4	Determine stresses in disk, beams, plates and hook using photo elastic bench.
CO5	Determination of Pressure distribution in Journal bearing
CO6	Analyse the stress and strains using strain gauges in compression and bending test and stress distribution in curved beams.

Contents	Hours/ Blooms Level
Part A Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional) Balancing of rotating masses Determination of critical speed of a rotating shaft. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell /Hartnel Governor.	**L1, L2, L3, L4**
Part B Determination of Fringe constant of Photoelastic material using. a) Circular disc subjected to diametral compression. b) Pure bending specimen (four-point bending. Determination of stress concentration using Photoelasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook. Determination of Pressure distribution in Journal bearing Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes. Determination of stresses in Curved beam using strain gauge.	**L1, L2, L3, L4**

<u>Scheme of Examination:</u>

One question from Part A: 40 marks

One question from Part B: 40 Marks

Viva voce: 20 Marks

Total: 100 Marks

OPEN ELECTIVE B

Energy and Environment

Open elective

VII Semester

Course Code	18ME751	CIE Marks	40
Number of Hours/Week	03L	SEE Marks	60
Total Number of Hours	40	Exam Hours	03
No. of Credits – 3			

Content	No. of Hours/RBT levels
Module 1 Basic Introduction to Energy: Energy and power, forms of energy, primary energy sources, energy flows, world energy production and consumption, Key energy trends in India: Demand, Electricity, Access to modern energy, Energy production and trade, Factors affecting India's energy development: Economy and demographics Policy and institutional framework, Energy prices and affordability, Social and environmental aspects, Investment.	**8 Hours** **L2, L3, L4**
Module 2 Energy storage systems: Thermal energy storage methods, Energy saving, Thermal energy storage systems Energy Management: Principles of Energy Management, Energy demand estimation, Energy pricing Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries. Economic Analysis: Scope, Characterization of an Investment Project.	**8 Hours** **L2, L3, L4**

Module 3 Environment: Introduction, Multidisciplinary nature of environmental studies- Definition, scope and importance, Need for public awareness. Ecosystem: Concept, Energy flow, Structure and function of an ecosystem. Food chains, food webs and ecological pyramids, Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystems, Ecological succession.	**8 Hours** **L2, L3, L4**
Module 4 Environmental Pollution: Definition, Cause, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, Solid waste Management, Disaster management Role of an individual in prevention of pollution, Pollution case studies.	**8 Hours** **L2, L3, L4**
Module 5 Social Issues and the Environment: Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation.	**8 Hours** **L2, L3, L4**

Course outcomes:

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

CO1	Understand energy scenario, energy sources and their utilization.
CO2	Understand various methods of energy storage, energy management and economic analysis.
CO3	Analyse the awareness about environment and eco system.
CO4	Understand the environment pollution along with social issues and acts

TEXT BOOKS:

1. Textbook for Environmental Studies for Undergraduate Courses of all Branches of Higher Education by University grant commission and Bharathi Vidyapeeth Institute of environment education and Research, Pune
2. Barun Kumar De, Energy Management Audit & Conservation, 2nd Edition, Vrinda Publication, 2010- for Module 2

REFERENCE BOOKS:

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th Edition, Fairmont Press, 2009.
2. Murphy, W. R., Energy Management, Elsevier, 2007.
3. Smith, C. B., Energy Management Principles, Pergamum, 2007.
4. Environment pollution control Engineering by C S Rao, New Age International, 2006, reprint 2015, 2nd edition.
5. Environmental studies, by Benny Joseph, Tata McGraw Hill, 2008, 2nd edition.

AUTOMOTIVE ENGINEERING

Open Elective

VII Semester

Subject Code	**18ME752**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**03**	**SEE Marks**	**60**
Total Number of Hours	**40**	**Exam Hours**	**03**

Credits – 03

Course Objectives:

- The layout and arrangement of principal parts of an automobile
- To learn fuel supply system ,cooling and lubrication system in IC engine
- To know the Injection system and its advancements
- The working of transmission and brake systems
- To know the automobile emissions and its effects on environment

Module - 1

ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams.

Mixture requirements in S.I engine. Simple Carburetor and its limitations. Theories of combustion process in S.I. engines. Normal and Abnormal combustion, Cetane and Octane numbers.

Module - 2

FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, Alternative fuels, , Types of carburetors, C.D.& C.C. carburetors, Multi point and Single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System, Multi-port fuel injection system.

COOLING AND LUBRICATION: Cooling requirements, Types of cooling- Thermo siphon system, Forced circulation water cooling system, Water pump, Radiator, Significance of lubrication, Splash and Forced feed system.

Module - 3

IGNITION SYSTEM: Battery Ignition system, Magneto Ignition system, electronic Ignition system. Battery, Purpose, Working principle of Lead acid battery, Methods of battery charging, determination of polarity of leads, dry charged battery, battery maintenance. Principle and operation of dynamo.

SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.

Module - 4

TRANSMISSION SYSTEMS: Clutch-Purpose and function, Single plate clutch, multiplate clutch gear boxes- manual and automatic, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

BRAKES: Purpose and function ,Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system.

Module - 5

AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter.

EMISSION STANDARDS: Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act

Course outcomes:

- To identify the different parts of an automobile and it's working
- To understand the working of transmission and braking systems
- To comprehend the working of steering and suspension systems
- To learn various types of fuels and injection systems
- To know the cause of automobile emissions, its effects on environment and methods to reduce the emissions.

TEXT BOOKS:

1. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011
2. Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.

REFERENCE BOOKS

1. Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007
2. Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
3. Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd.
4. Automobile Engineering, R. B. Gupta, Satya Prakashan,(4th Edition) 1984.

INDUSTRIAL SAFETY

OPEN ELECTIVE

VII SEMESTER

Course Code	18ME753	CIE Marks	40
Number of Hours/Week	03L	SEE Marks	60
Total Number of Hours	40	Exam Hours	03
No. of Credits – 3			

Course Objectives:

- The present course highlights the importance of general safety and its prevention.
- It enables students to understand about mechanical, electrical sand chemical safety.
- The Industrial safety course helps in motivating the students to understand the reason for fire
- Its Controlling of fire by various means are highlighted.
- Importance of chemical safety, labelling of chemicals, hand signals during forklift operations in industrial and aerodromes will help in to understand and apply the techniques in practical field.
- A visit to campus, various labs, workshops, local industries and fire stations helps in analyzing the importance of safety and corrective measures through case studies.

MODULE1: INTRODUCTION TO SAFETY

Terms used: accident, safety, hazard, safe, safety devices, safety guard, security, precaution, caution, appliance, slip, trip, fall.

Ladders and scaffolding. Unsafe acts, reason for accidents, MSDS (material safety data sheet), computer Aided Hazard Analysis, International acts and standards OSHA, WHO. Environment act, control and abatement of environmental pollution-Biomedical waste. Lockout and tag out procedures. Safe material handling and storage. Risk analysis quantification.

Case studies: Student should identify the unsafe acts near their surroundings like housekeeping, lab as well as industrial layouts, road safety, campus layout, safety signs. **08 hours**

MODULE 2: FIRE SAFETY

Introduction, toxicity of products of combustion – vapour clouds – flash fire – jet fires – pool fires – auto-ignition, sources of ignition . Class A, B, C, D and E fire. Fire triangle, Fire extinguishers, Fire hazard and analysis, prevention of fire. Fire protection and loss prevention, steps after occurrence of fire. notice-first aid for burns, Portable fire extinguishers. Fire detection, fire alarm and fire fighting systems. Safety sign boards, instruction on portable fire extinguishers.

Case studies: demonstration of fire extinguishers, visit to local fire fighting stations. Visit to fire accident sites to analyze the cause of fire and its prevention for future.

08 Hours

MODULE 3: MECHANICAL SAFETY

PPE, safety guards, Mechanical hazards, workplace hazards, Forklift hazard control

Safety while working with machine tools like lathe, drill press, power and band saws, grinding machines. Safety during welding, forging and pressing.

Safety while handling Material, compressed gas cylinders, corrosive substance, waste drum and containers.

Case studies: Visit to machine shop, workshops, foundry lab and local industries to record the practical observation and report the same with relevant figures and comments.

08 Hours

MODULE-4: ELECTRICAL SAFETY

Introduction to electrical safety, Indian standards on electrical safety, Electric hazards, effect of electric current on human body, causes of electrical accidents, prevention of electric accidents, PPE used . Protection systems: Fuse, circuit breakers and overload relays – protection against over voltage and under voltage. Electric shock. Primary and secondary electric shocks, AC and DC current shocks. Safety precautions against shocks. Safety precautions in small and residential building intallations. Safety procedures in electric plant.

Case studies: To visit electrical sub stations, local distribution systems, observe and share the experience and report.

08 Hours

MODULE 5: CHEMICAL SAFETY AND OTHER SAFETY CHECKS

Introduction to Chemical safety, Labelling of chemicals, acid hoods. Handling of acids, eye washers and showers. Safety thinking, accident investigation, safety policy of the company, safety, loss prevention and control, check list for LPG installations, safety precautions using CNG, fire prevention and safety audit, confined space entry, risk assessment.

Case studies: To visit chemical laboratory of the college and other chemical industries like LPG , CNG facilities and report.

08 Hours

Course Outcomes:

After completing the course, the students will be able to:

CO1: Understand the basic safety terms and international standards.

CO2:. Identify the hazards and risk analysis around the work environment and industries.

CO3: Use the safe measures while performing work in and around the work area of the available laboratories. Able to recognize the sign boards and its application.

CO4: Recognise the types of fires extinguishers and their to demonstrate the portable extinguishers used for different classes of fires.

CO5: Report the case studies by sharing experience of the employees working in housekeeping, laboratories like workshops, electrical labs, machine shops, electronics and computer laboratories.

CO6: Recognise the chemical and electrical hazards for its prevention and control.

Text Books:

1- Industrial Safety and Management by L M Deshmukh by McGraw Hill Education (India) private Limited, ISBN-13: 978-0-07-061768-1, ISBN-10: 0-07-061768-6
2- Derek, James, "Fire Prevention Hand Book", Butter Worth's and Company, London, 1986
3- Electrical Safety, fire safety and safety management by S.Rao, R K Jain and Saluja. Khanna Publishers, ISBN: 978-81-7409-306-6
4- Industrial health and safety management by A.M.Sarma,Himalya publishing house
5- Chemical process Industrial safety by K S N Raju by McGraw Hill Education (India) private Limited, ISBN-13: 978-93-329-0278-7, ISBN-10:93-329-0278-X
6- Environmental engineering by Gerard Kiely by McGraw Hill Education (India) private Limited, ISBN-13: 978-0-07-063429-9

Reference books:

1- The Factories Act 1948, Madras Book Agency
2- The Environment Act (Protection) 1986, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.
3-Water (Prevention and control of pollution) act 1974, Commercial Law publishers (India) Pvt.Ltd. New Delhi.
4 Air (Prevention and control of pollution) act 1981, Commercial Law

VISITS:

1- To visit respective Institution: stores, office, housekeeping area, laboratories.

2- To visit local industries, workshops, district fire fighting system facility and local electrical power stations.

Optimisation Techniques

Open elective

VII Semester

Subject Code	**18ME754**	**CIE Marks**	**40**
Number of Hours/Week	**3L**	**SEE Marks**	**60**
Total Number of Hours	**3**	**Exam. Hours**	**03**
Number of Credits: 3			

Contents	**Hours/ RBT Levels**
Module –I: Introduction: Statement of optimisation problem, Design vector, Design constraints, Objective function, Classification of optimisation problems based on :constraints, nature of design variables, nature of the equations involved **Single variable optimisaton:** Necessary and sufficient conditions, Multivariable optimization with no constraints: Necessary and sufficient conditions, Semidefinite case, Saddle point, Multivariable optimization with equality constraints, Solution by direct substitution, Lagrange Multipliers, Interpretation of Lagrange multipliers, Multivariable optimization with inequality constraints: Khun Tucker conditions(concept only)	**10 Hours** **L2, L3, L4**
Module II: Nonlinear Programming: One-Dimensional Minimization Methods Introduction, Unimodal Function, Elimination methods: unrestricted search, fixed step size, accelerated step size, Exhaustive search: dichotomous search, interval halving method, Fibonacci method, golden section method, Interpolation methods: Quadratic and cubic interpolation method, direct root method, Newton method, Quasi-Newton method, secant method	**12 Hours** **L2, L3, L4**
Module III: Nonlinear Programming: Direct search methods: Classification of unconstrained minimization methods, rate of convergence, scaling of design variables, random search methods , univariate method, pattern directions, Powell's method, Simplex method.	**06 Hours** **L2,L3**
Module IV: Nonlinear Programming: Indirect Search (Descent) Methods: Gradient of a function, Steepest decent method, Fletcher Reeves method, Newtons method, Davidon-Fletcher-Powell method.	**06 Hours** **L2,L3**

Module V: Integer Programming: Introduction, Graphical representation, Gomory's cutting plane method: concept of a cutting plane, Gomory's method for all-integer programming problems, Balas' algorithm for zero–one programming, Branch-and-Bound Method.	**06 Hours** **L2,L3**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Define and use optimization terminology, concepts, and understand how to classify an optimization problem.
CO2	Understand how to classify an optimization problem.
CO3	Apply the mathematical concepts formulate the problem of the systems.
CO4	Analyse the problems for optimal solution using the algorithms.
CO5	Interpret the optimum solution.

Text Books:

1. S. S. Rao , Engineering Optimization Theory and Practice, Fourth Edition, John Wiley & Sons, 2009.

Reference Books:

1. A. D. Belegundu, T.R. Chanrupatla, Optimisation Concepts and Applications in Engineering, Cambrige University Press,2011

2. Ravindran, K. M. Ragsdell, and G. V. Reklaitis, Engineering Optimization: Methods and Applications, 2nd ed., Wiley, New York, 2006.

VIIII SEMESTER MECHANICAL 2018 SCHEME

ENERGY ENGINEERING VIII Semester			
Subject Code	**18ME81**	**CIE Marks**	**40**
Number of Hours/Week	**03**	**SEE Marks**	**60**
Total Number of Lecture Hours	**40**	**Exam Hours**	**03**
No. of Credits: 3			

Course Objectives:

- Understand energy scenario, energy sources and their utilization
- Learn about energy conversion methods
- Study the principles of renewable energy conversion systems

Module 1	**8 Hours**
STEAM GENERATORS Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures, LaMount, Benson, Velox, Loeffer, Schmidt steam generators, Chimneys-Natural, forced, induced and balanced draft systems, Cooling towers and Ponds, Accessories such as Superheaters, De-superheater, Economizers, Air preheaters.	
Module 2	**8 Hours**
Solar Energy: Introduction, Solar radiation at the earth's surface, Solar radiation measurements, Flat plate collectors, Focussing collectors, Solar pond, Solar electric power generation-Solar photovoltaics. **Biomass Energy**: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation. Thermal gasification of biomass, updraft and downdraft gasifiers.	

Module 3	8 Hours
Geothermal Energy: Forms of geothermal energy, Dry steam, wet steam, hot dry rock and magmatic chamber systems. **Tidal Energy**: Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy. **Wind Energy**: Wind energy-Advantages and limitations, wind velocity and wind power, Basic components of wind energy conversion systems, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor, Applications of wind energy.	
Module 4	**8 Hours**
Hydroelectric plants: Advantages & disadvantages of water power, Hydrographs and flow duration curves-numericals, Storage and pondage, General layout of hydel power plants-components such as Penstock, surge tanks, spill way and draft tube and their applications, pumped storage plants, Detailed classification of hydroelectric plants, water hammer. **Ocean Thermal Energy**: Ocean thermal energy conversion, Principle and working of Rankine cycle, Problems associated with OTEC.	
Module 5	**8 Hours**
NUCLEAR ENERGY Principles of release of nuclear energy-Fusion and fission reactions. Nuclear fuels used in the reactors, Chain reaction, Moderation, breeding, Multiplication and thermal utilization factors. General components of a nuclear reactor and materials, Brief description-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shielding, Nuclear waste, Radioactive waste disposal.	

Course outcomes:

- Understand the construction and working of steam generators and their accessories.
- Identify renewable energy sources and their utilization.
- Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, nuclear, hydel and tidal.

TEXT BOOKS:

1. Power Plant Engineering, P. K. Nag, Tata McGraw Hill Education Private Limited, New Delhi, Third Edition, 2012.
2. Power Plant Engineering, Arora and Domkundwar, Dhanpat Rai & Co. (P) Ltd., Sixth Edition, 2012.
3. Non-conventional Sources of Energy, G.D.Rai, Khanna Publishers, New Delhi, Fifth Edition, 2015.
4. B H Khan, Non conventional energy resources, 3rd Edition, McGraw Hill Education

REFERENCE BOOKS

1. Power Plant Engineering, R. K. Rajput, Laxmi publication, New Delhi.
2. Principles of Energy conversion, A. W. Culp Jr., McGraw Hill. 1996.
3. Power Plant Technology, M.M. EL-Wakil, McGraw Hill International, 1994.
4. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).

PROFESSIONAL ELECTIVE 4

CNC MACHINE TOOLS

VII Semester

Subject Code	**18ME821**	**CIE Marks**	**40**
Hours / Week	**03**	**SEE Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. Of Credits: 3			

Course objectives:

CLO1	To understand fundamentals of the CNC technology.
CLO2	To get exposed to constructional features of CNC machine tools.
CLO3	To know the concepts of CNC machine tool drives and feedback systems.
CLO4	To understand the programming methods in CNC machines.
CL05	To understand the cutting tools used, and work holding devices on CNC machine tools.

Content	**No. of Hours/RBT levels**
Module 1	**6 Hours**
INTRODUCTION TO CNC MACHINE TOOLS: Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning centre, machining centre, grinding machine, EDM, types of control systems, CNC controllers, characteristics, interpolators– Computer Aided Inspection.	**L1, L2, L3**

Module 2 **STRUCTURE OF CNC MACHINE TOOL:** CNC Machine building, structural details, configuration and design, guide ways – Friction, Anti friction and other types of guide ways, elements used to convert the rotary motion to a linear motion – Screw and nut, recirculating ball screw, planetary roller screw, recirculating roller screw, rack and pinion, spindle assembly, torque transmission elements – gears, timing belts, flexible couplings, Bearings.	**10 Hours** **L2, L3, L4**
Module 3 **DRIVES AND CONTROLS:** Spindle drives – DC shunt motor, 3 phase AC induction motor, feed drives –stepper motor, servo principle, DC and AC servomotors, Open loop and closed loop control, Axis measuring system – synchro, synchro-resolver, gratings, moiré fringe gratings, encoders, inductosysn, laser interferometer.	**8 Hours** **L1, L2, L3**
Module 4 **CNC PROGRAMMING:** Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image, parametric programming, machining cycles, manual part programming for machining centre and turning centre. Computer Aided CNC Part Programming: Need for computer aided part programming, Tools for computer aided part programming, APT, CAD/CAM based part programming for well-known controllers such as Fanuc, Heidenhain, Sinumerik etc., and generation of CNC codes from CAM packages.	**8 Hours** **L2, L3, L4**
Module 5 **TOOLING AND WORK HOLDING DEVICES:** Introduction to cutting tool materials – Carbides, Ceramics, CBN, PCD–inserts classification, qualified, semi qualified and preset tooling, tooling system for Machining centre and Turning centre, work holding devices for rotating and fixed work parts, modular fixtures, economics of CNC, maintenance of CNC machines.	**8 Hours** **L2. L3, L4**

Course Outcomes:
After learning the course the students should be able to:

CO1	Understand evolution, classification and principles of CNC machine tools.
CO2	Learn constructional details of CNC machine tools, selection of standard components used for CNC machine tools for accuracy and productivity enhancement.
CO3	Select drives and positional transducers for CNC machine tools.
C04	Apply CNC programing concepts of for two axis turning centers and three axis vertical milling centers to generate programs different components.
CO5	Generate CNC programs for popular CNC controllers.
CO6	Analyse and select tooling and work holding devices for different components to be machined on CNC machine tools.

TEXT BOOKS:

- HMT, "Mechatronics", Tata McGraw-Hill Publishing Company Limited, New Delhi. 2005.
- Koren Y, Computer Control of Manufacturing systems, McGraw Hill, 1986.
- Radhakrishnan P, "Computer Numerical Control Machines", New Central Book Agency, 2002.

REFERENCES:

- James Madison, "CNC Machining Hand Book", Industrial Press Inc., 1996.
- Ken Evans, John Polywka & Stanley Gabrel, "Programming of CNC Machines", Second Edition, Industrial Press Inc, New York, 2002.
- Peter Smid, "CNC Programming Hand book", Industrial Press Inc., 2000
- Berry Leathan – Jones, "Introduction to Computer Numerical Control", Pitman, London, 1987.
- Rao P.N., "CAD/CAM", Tata McGraw-Hill Publishing Company Limited, New Delhi,2002.
- Warren S. Seamers, "Computer Numeric Control", Fourth Edition, Thomson Delmar, 2002.

TRIBOLOGY

SEMESTER VIII

Subject Code	**18ME822**	**IA Marks**	**40**
Hours / Week	**03**	**Exam Marks**	**60**
Total Hours	**40**	**Exam Hours**	**03**
No. of Credits: 3			

Course objectives:

CLO1	To educate the students on the importance of friction, the related theories/laws of sliding and rolling friction and the effect of viscosity of lubricants.
CLO2	To expose the students to the consequences of wear, wear mechanisms, wear theories and analysis of wear problems.
CLO3	To make the students understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
CLO4	To expose the students to the factors influencing the selection of bearing materials for different sliding applications.
CLO5	To introduce the concepts of surface engineering and its importance in tribology.

Content	**No. of Hours/RBT levels**
Module 1 **Introduction to tribology:** Historical background, practical importance, and subsequent use in the field. Lubricants: Types and specific field of applications. Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.	**8 Hours** **L1, L2, L3**
Module 2 **Friction:** Origin, friction theories, measurement methods, friction of metals and non-metals.	**8 Hours** **L1, L2, L3**

Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies.	
Module 3 **Hydrodynamic journal bearings:** Friction forces and power loss in a lightly loaded journal bearing, Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D. Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium, Sommerfeld's number and it's significance; partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.	**8 Hours** **L2, L3, L4**
Module 4 **Plane slider bearings with fixed/pivoted shoe:** Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples. **Hydrostatic Lubrication:** Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples.	**8 Hours** **L2, L3, L4**
Module 5 **Bearing Materials:** Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials. **Introduction to Surface engineering:** Concept and scope of surface engineering. Surface modification – transformation hardening, surface melting, thermo chemical processes. Surface Coating – plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.	**8 Hours** **L1, L2, L3**

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	**Understand** the fundamentals of tribology and associated parameters.
CO2	**Apply** concepts of tribology for the performance analysis and design of components experiencing relative motion.
CO3	**Analyse** the requirements and design hydrodynamic journal and plane slider bearings for a given application.

CO4	**Select** proper bearing materials and lubricants for a given tribological application.
CO5	**Apply** the principles of surface engineering for different applications of tribology.

Note: Use of approved Design Data Handbook/charts can be permitted during the examination.

TEXTBOOKS:

1."Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002
2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011.
3. "Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.

REFERENCES:

1. "Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing.
2. "Tribology, Friction and Wear of Engineering Material", I. M.Hutchings, Edward Arnold, London, 1992.
3. "Engineering Tribology", G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann, 1992.
4. "Friction and Wear of Materials", Ernest Rabinowicz, John Wiley & sons, 1995.
5. "Basic Lubrication Theory", A. Cameron, Ellis Hardwoods Ltd., UK.
6. "Handbook of tribology: materials, coatings and surface treatments", B.Bhushan, B.K. Gupta, McGraw-Hill, 1997.

NON-DESTRUCTIVE TESTING OF MATERIALS

VIII SEMESTER

Subject Code	**18 ME 823**	**CIE Marks**	**40**
Hours/Week	**03**	**SEE Marks**	**60**
Total Hours	**42**	**Exam Hours**	**03**
No. of Credits: 3			

COURSE OBJECTIVES:

CLO1	To introduce the basic principles, techniques, equipment, applications and limitations of NDT methods such as Visual, Penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography, Eddy Current.
CLO2	To enable selection of appropriate NDT methods.
CLO3	To identify advantages and limitations of nondestructive testing methods
CLO4	To make aware the developments and future trends in NDT.

MODULE 1 **OVERVIEW OF NDT:** NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT., Visual inspection – Unaided and aided.	**7 Hours** **L1, L2, L3**
MODULE 2 SURFACE NDE METHODS: Liquid Penetrant Testing – Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials, magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.	**8 Hours** **L1, L2, L3, L4**

MODULE 3 THERMOGRAPHY AND EDDY CURRENT TESTING (ET): Thermography- Principles, Contact and non -contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.	**8 Hours** **L1, L2, L3, L4**
MODULE 4 ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE): Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique –Principle, AE parameters, Applications.	**8 Hours** **L1, L2, L3**
MODULE 5 RADIOGRAPHY (RT): Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.	**8 Hours** **L1, L2, L3**

Course Outcomes:

CO1	Classify various nondestructive testing methods.
CO2	Check different metals and alloys by visual inspection method.
CO3	Explain and perform non-destructive tests like: Liquid penetrant test, Magnetic particle test, Ultrasonic test, X-ray and Gamma ray radiography, Leak Test, Eddy current test.
CO4	Identify defects using relevant NDT methods.
CO5	Differentiate various defect types and select the appropriate NDT methods for better evaluation.
CO6	Document the testing and evaluation of the results.

TEXT BOOKS:

- Baldev Raj, T.Jayakumar, M.Thavasimuthu “Practical Non-Destructive Testing”, Narosa Publishing House, 2009.
- Ravi Prakash, “Non-Destructive Testing Techniques”, 1st revised edition, New Age International Publishers, 2010

REFERENCES:

- ASM Metals Handbook,”Non-Destructive Evaluation and Quality Control”, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
- Paul E Mix, “Introduction to Non-destructive testing: a training guide”, Wiley, 2nd Edition New Jersey, 2005
- Charles, J. Hellier,“ Handbook of Nondestructive evaluation”, McGraw Hill, New York 2001.
- ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

AUTOMOBILE ENGINEERING

VIII Semester

Subject Code	18ME824	CIE Marks	40
Number of Hours/Week	03L	SEE Marks	60
Total Number of Hours	40	Exam Hours	03
No. of Credits: 3			

Course Objectives:

- To know layout and arrangement of principal parts of an automobile.
- To understand the working of transmission and brake systems.
- To comprehend operation and working of steering and suspension systems.
- To know the Injection system and its advancements.
- To know the automobile emissions and its effects on environment.

Module 1	
ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, engine positioning. Concept of HCCI engines, Hybrid engines, Twin spark engine, Electric car. **COOLING AND LUBRICATION**: Cooling requirements, Types of cooling- Thermo siphon system, Forced circulation water cooling system, Water pump, Radiator, Significance of lubrication, Splash and Forced feed system.	**8 Hours** **L1, L2, L3**
Module 2	
TRANSMISSION SYSTEMS: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints. Differential and rear axle, Hotchkiss Drive and Torque Tube Drive. **BRAKES**: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock, & Numerical.	**8 Hours** **L1, L2, L3**

Module 3	
STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system. **IGNITION SYSTEM**: Battery Ignition system, Magneto Ignition system, electronic Ignition system.	**8 Hours** **L1, L2, L3**
Module 4	
SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag. **FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES**: Conventional fuels, Alternative fuels, Normal and Abnormal combustion, Cetane and Octane numbers, Fuel mixture requirements for SI engines, Types of carburetors, C.D.& C.C. carburetors, Multi point and Single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System.	**8 Hours** **L1, L2, L3**
Module 5	
AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter. **EMISSION STANDARDS:** Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act	**8 Hours** **L1, L2, L3, L4**

Course outcomes:

- Identify the different parts of an automobile and it's working.
- Understand the working of transmission and braking systems.
- Understand the working of steering and suspension systems and their applications.
- Selection and applications of various types of fuels and injection systems.
- Analyse the cause of automobile emissions, its effects on environment and methods to reduce the emissions.

TEXT BOOKS:

1. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011
2. Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.

REFERENCE BOOKS

1. Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007
2. Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
3. Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd.
4. Automobile Engineering, R. B. Gupta, Satya Prakashan,(4th Edition) 1984.

SEMESTER – VI

TOOL DESIGN

Subject Code	**18 ME 825**	**CIE Marks**	**40**
Hours/Week	**03L**	**SEE Marks**	**60**
Total Hours	**42**	**Exam Hours**	**03**
No. of Credits: 3			

Course Objectives:

CLO1	To develop capability to design and select single point and multipoint cutting tools for various machining operations.
CLO2	Exposure to variety of locating and clamping methods available.
CLO3	To enable the students to design jigs and fixtures for simple components.
CLO4	To expose the students to the design/selection procedure of press tools and die casting dies.

Content	**No. of Hours/RBT levels**
Module 1	**8 Hours**
Introduction to tool design: Tooling, requirements of a tool designer, general tool design procedure, tool engineering functions and its importance to enhance productivity and quality. Review of cutting tool materials. Tool angles and signature, Carbide inserts grades - ISO designation and applications, tool holders for turning-ISO designation. Solid type tool, brazed tip tool, throwaway indexable insert types, coated carbides and chip breakers. Design of single point cutting tools: Design of shank dimensions using strength and rigidity considerations for rectangular, square and round cross section and selection of tool geometry.	**L1, L2, L3**
Module 2	**8 Hours**

Design of Multi Point Cutting Tools: Types of drills, Drill bit design - elements like back taper, web thickness, land width, margin, flute length and cross section and selection of tool geometry. Re-sharpening of drill bit. Tool holders for milling, different tapers used for mounting tool holders in milling, ISO designation. Tool mounting systems. Design of milling cutters: Design of elements like number of teeth and height, circular pitch, body thickness, chamfer width, fillet radius and selection of tool geometry. Profile sharpened and form relieved milling cutters. Re-sharpening of side and face milling cutter and end mill.	**L2, L3, L4**
Module 3	**8 Hours**
Jigs and Fixtures: Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices, and power clamping. Drill bushes; Drill jigs: different types, exercises of designing jigs for simple components. Fixture Design: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centers, and modular fixtures. Design exercises on fixtures for turning and milling for simple components.	**L2, L3, L4**
Module 4	**8 Hours**
Press tools: Classification and working of power presses. Concept and calculations of press tonnage and shut height of a press, components of a simple die, press tool operation, die accessories, shearing action in punch & die, clearance, shear on punch and die, Centre of pressure, and strip layout. Simple, progressive, compound, combination and inverted dies. Design problems on blanking and piercing dies for simple components. **Bending dies** – Introduction, bend allowance, spring back, edge bending die design.	**L2, L3, L4**
Module 5	**8 Hours**
Drawing dies – Single action, double action and triple action dies, factors affecting drawing and drawing die design. Design of drawing dies for simple components.	**L2, L3, L4**

Die casting: Die casting alloys, terminology- core, cavity, sprue, slug, fixed and movable cores, finger cams, draft, ejector pins and plates, gate, goose nozzle, over-flow, platten, plunger, runner, vent, water-line etc. Types of Dies: Single cavity, multi cavity dies, combination dies, unit dies, advantages and disadvantages of types of dies; finishing, trimming and inspection of die casting components, safety, and modern trends in die casting dies.	

Assignment:

Course work includes a **Tool Design project**. Tool design project should enable the students to design a tooling like Jig or a fixture for a simple component, fixture for a simple component on CNC machining centers, design of a simple blanking and piercing die, progressive die, drawing die etc. Any one of these exercises should be given as an assignment. A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Tool design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Tool design project should be given due credit in internal assessment.

Course Outcomes:

After learning the course the students should be able to:

CO1	Select appropriate cutting tools required for producing a component.
CO2	Understand and interpret cutting tool and tool holder designation systems.
CO3	Select suitable locating and clamping devices for a given component for various operations.
CO4	Analyze and design a jig/fixture for a given simple component.
CO5	Understand various press tools and press tool operations.
CO6	Classify and explain various die casting and injection moulding dies.

Textbooks:

[1] Cyril Donaldson, George H. Lecain, V.C.Goold, "Tool Design", Mc Graw Hill Education, 5th edition, 2017.

[2] P.N.Rao, "Manufacturing technology", Mc Graw Hill Education, 4th edition, 2013.

References:

[1] P.H.Joshi, "Jigs and Fixtures", Mc Graw Hill Education, 3rd edition, 2010.

[2] John.G. Nee, William Dufraine, John W. Evans, Mark Hill, "Fundamentals of Tool Design", Society of Manufacturing Engineers, 2010.

[3] Frank W.Wilson, "Fundamentals of Tool Design", PHI publications.

[4] Kempester M.H.A., "An introduction to Jig and Tool design", VIVA Books Pvt.Ltd., 2004.

[5] Ranganath B.J., “Metal cutting and Tool Design”, Vikas publishing house.
[6] HMT, “Production Technology”, Tata Mc Graw Hill, 2013.
[7] V. Arshinov & G. Alekseev, “Metal cutting theory and practice”, MIR publishers, Moscow.
[8] Rodin, “Design and production of metal cutting tools”, Beekman publishers.