DAYANANDA SAGAR UNIVERSITY

ShavigeMalleshwara Hills, Kumaraswamy Layout,

Bengaluru - 560078, Karnataka.

SCHOOL OF ENGINEERING

SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2019

MECHANICAL ENGINEERING

(3rd to 8th Sem)

(WITH EFFECT FROM 2019 - 20)

SCHEME - B.TECH – 2019-20 ONWARDS

III SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/ P	C	SEM	COURSE CODE
1	105	19ME2301	ENGINEERING MATHEMATICS – III - **MECH & ASE**	CR	03	01	--	--	04	*	***
2	105	19ME2302	ENGINEERING MATERIALS	CR	03	--	02	--	04	*	***
3	105	19ME2303	ENGINEERING MECHANICS	CR	03	--	--	--	03	*	***
4	105	19ME2304	THERMODYNAMICS	CR	03	--	--	--	03	*	***
5	105	19ME2305	COMPUTER AIDED MACHINE DRAWING	CR	02	--	04	---	04	II	19EN1271
6	105	19ME2306	MECHANICAL MEASUREMENTS	CR	03	--	02	--	04	*	***
7	105	19ME2307	SPECIAL TOPICS – I	CR	02	--	--	--	02	*	***
					19	**01**	**08**	**-**	**24**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

SCHEME - B.TECH – 2019-20 ONWARDS

IV SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	19ME2401	APPLIED THERMODYNAMICS	CR	02	01	02	--	04	III	19ME2304
2	105	19ME2402	MECHANICS OF MATERIALS	CR	02	01	--	--	03	III	19ME2303
3	105	19ME2403	FLUID MECHANICS AND MACHINES	CR	03	--	02	--	04	*	***
4	105	19ME2404	MANUFACTURING PROCESS	CR	03	--	02	--	04	*	***
5	105	19ENC003	ECONOMICS FOR ENGINEERS	CR	02	--	--	--	02	*	***
6	105	19ME2405	SPECIAL TOPICS – II	CR	02	--	--	--	02	*	***
					14	**02**	**06**	**--**	**19**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

SCHEME - B.TECH – 2019-20 ONWARDS

V SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	19ME3501	HEAT TRANSFER	CR	03	--	02	--	04	III	19ME2304
2	105	19ME3502	KINEMATICS & THEORY OF MACHINES	CR	03	01	--	--	04	*	***
3	105	19ME3503	DESIGN OF MACHIN ELEMENTS – I	CR	02	01	02	--	04	IV	19ME2402
4	105	19ME3504	MANUFACTURING TECHNOLOGY	CR	03	--	02	--	04	IV	19ME2404
5	105	19ME35XX	PROFESSIONAL ELECTIVE – I	CR	03	--	--	--	03	AS INDICATED IN PROGRAM ELECTIVE LIST	
6	105	19OEXXXX	OPEN ELECTIVE – I	CR	03	--	--	--	03	*	***
7	105	19ME3505	SPECIAL TOPICS – III	CR	02	--	--	--	02	*	***
					19	**02**	**06**	**--**	**24**		

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PROGRAM ELECTIVE – I				
SL.NO	COURSE CODE	COURSE TITLE	PREREQUISITE	
			SEM	COURSE CODE
1	19ME3506	REFRIGERATION AND AIR CONDITIONING	IV	19ME2401
2	19ME3507	QUALITY AND RELIABILITY ENGINEERING	*	***
3	19ME3508	NON-DESTRUCTIVE EVALUATION AND TESTING	*	***
4	19ME3509	TOOL DESIGN	*	***
5	19ME3510	INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	*	***

SCHEME - B.TECH – 2019-20 ONWARDS

VI SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	19ME3601	DESIGN OF MACHINE ELEMENTS – II	CR	02	01	02	--	04	IV	19ME2402
2	105	19ME3602	FINITE ELEMENT ANALYSIS	CR	02	01	02	--	04	I	19EN1101
3	105	19ME3603	MECHANICAL VIBRATIONS	CR	03	--	02	--	04	II	19EN1201
4	105	19ME36XX	PROFESSIONAL ELECTIVE – II	CR	03	--	--	--	03	AS INDICATED IN PROGRAM ELECTIVE LIST	
5	105	19ME36XX	PROFESSIONAL ELECTIVE – III	CR	03	--	--	--	03		
6	105	19OEXXXX	OPEN ELECTIVE – II	CR	03	--	--	--	03		
7	105	19ENXXXX	LAW FOR ENGINEERS	CR	02	--	-	--	02		
					18	**02**	**06**	**--**	**23**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – II				
SL.NO	**COURSE CODE**	**COURSE TITLE**	**PREREQUISITE**	
			SEM	**COURSE CODE**
1	19ME3604	PRODUCT DESIGN AND MANUFACTURING	*	***
2	19ME3605	SURFACE ENGINEERING	*	***
3	19ME3606	RENEWABLE ENERGY SOURCES	III	19ME2304
4	19ME3607	ROBOTICS	V	19ME3502
5	19ME3608	COMPUTER AIDED DESIGN	*	***
PROGRAM ELECTIVE – III				
1	19ME3609	PRINCIPLES OF FRACTURE MECHANICS	IV	19ME2402
2	19ME3610	INTERNAL COMBUSTION ENGINES	IV	19ME2401
3	19ME3611	MODELLING AND SIMULATION OF MANUFACTURING SYSTEMS	V	19ME3504
4	19ME3612	ADVANCED MATERIAL TECHNOLOGY	III	19ME2302
5	19ME3613	DEEP LEARNING & IMAGE PROCESSING	*	***

SCHEME - B.TECH – 2019-20 ONWARDS

VII SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	19ME4701	CONTROL SYSTEMS ENGINEERING	CR	03	--	02	--	04	II	19EN1201
2	105	19ME47XX	PROFESSIONAL ELECTIVE – IV	CR	03	--	--	--	03	AS INDICATED IN PROGRAM ELECTIVE LIST	
3	105	19ME47XX	PROFESSIONAL ELECTIVE – V	CR	03	--	--	--	03		
4	105	19OEXXXX	OPEN ELECTIVE – III	CR	03	--	--	--	03	*	***
5	105	19ME4702	MAJOR PROJECT PHASE – I	CR	--	--	--	04	02	*	***
					12	**-**	**02**	**04**	**15**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – IV				
SL.NO	COURSE CODE	COURSE TITLE	PREREQUISITE	
			SEM	COURSE CODE
1	19ME4703	ADVANCED MACHINING PROCESSES	IV	19ME2404
2	19ME4704	GAS DYNAMICS AND JET PROPULSION	IV	19ME2403
			V	19ME3501
3	19ME4705	MEMS (MICRO ELECTRO MECHANICAL SYSTEMS)	*	***
4	19ME4706	COMPOSITE MATERIALS	III	19ME2302
5	19ME4707	OPERATION RESEARCH	*	***
PROGRAM ELECTIVE – V				
1	19ME4708	RAPID MANUFACTURING TECHNOLOGIES	V	19ME3504
2	19ME4709	DESIGN FOR MANUFACTURING	*	***
3	19ME4710	COMPUTATIONAL FLUID DYNAMICS	IV	19ME2403
			V	19ME3501
4	19ME4711	OPERATIONS MANAGEMENT	*	***

SCHEME - B.TECH – 2019-20 ONWARDS

VIII SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	19ME48XX	PROFESSIONAL ELECTIVE – VI	CR	03	--	--	--	03	AS INDICATED IN PROGRAM ELECTIVE LIST	
2	105	19ME4801	MAJOR PROJECT PHASE– II	CR	--	--	--	20	10	VII	19ME4702
					03	**-**	**-**	**10**	**13**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – VI				
SL.NO	COURSE CODE	COURSE TITLE	PREREQUISITE	
			SEM	COURSE CODE
1	19ME4802	TRIBOLOGY AND BEARING DESIGN	VI	19ME3601
2	19ME4803	PLASTIC PROCESSING TECHNOLOGY	*	***
3	19ME4804	AUTOMOBILE ENGINEERING	*	***
4	19ME4805	FUELS AND COMBUSTION	IV	19ME2401

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 19ME2301
TITLE OF THE COURSE : ENGINEERING MATHEMATICS – III – MECH & ASE
L: T: P: S/P: C : 04:00:00:00:04

MODULE 1 [8 hours]
3-D GEOMETRY
3-D Coordinate systems, Vectors, Dot and Cross products, Lines, planes and curves in space, Tangents to curves, Normal vectors of curve.

MODULE 2 [**14 Hours**]
MULTI VARIABLE CALCULUS
DIFFERENTIAL CALCULUS:
Functions of two or more real variables, Partial derivatives of second and higher order, Euler's theorem on homogenous function, Total derivatives, Jacobians, Maxima and minima, Lagrange's method of undetermined multipliers, Taylor's formula for two variables

INTEGRAL CALCULUS
Double integrals, Triple integrals, Change of order of integration in a double integral, Change of variables in double and triple integrals, Area as a double integral, Volume as a triple integral, Line integrals, Vector Fields and Line integrals.

MODULE 3 [12 hours]
GREEN'S, STOKE'S AND DIVERGENCE THEOREMS
Path independence, Green's theorem, Surfaces and area, Surface Integrals, Stoke's Theorem, Divergence Theorem.

MODULE 4 NUMERICAL METHODS - I [8 hours]
Introduction to Numerical methods, Initial and Boundary value problems, Numerical solution of ODE, Picard's method, Taylors series method, Euler's method, Modified Euler's method, Runge-Kutta method

MODULE 5 NUMERICAL METHODS - II [10 hours]
Introduction of PDE, Classification of PDE: parabolic, elliptic and hyperbolic. Boundary and initial conditions, Taylor series expansion, analysis of truncation error, Finite difference method: FD, BD & CD, Higher order approximation, Order of Approximation, Polynomial fitting, One-sided approximation.

Text Books:
1. Thomas's Calculus, G.B.Thomas, M.Weir, J. Hass, Pearson , 12th edition
2. Advanced Engineering Mathematics, E. Kreyzsig, Wiley, 10th Edition
3. Numerical Methods for Engineers, Chapra and Canale, Mc Graw Hill Education, 7 th edition.

Reference Books:
- Basic Multi Variable Calculus, Marsden, Tromba and Weinstein, W.H. Freeman, Third Edition
- A First Course in Numerical Methods, Ascher and Grief, SIAM 2011
- Higher Engineering mathematics, BS Grewal, 43rd Edition, Khanna publishers.

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 19ME2302
TITLE OF THE COURSE : ENGINEERING MATERIALS
L: T: P: S/P: C : 03:00:02:00:04

Course Objectives

The objectives of the Course are to:

- Describe the difference in atomic/molecular structure between crystalline and non-crystalline materials
- Distinguish between single crystals and polycrystalline materials
- Describe the different types of defects in materials
- Describe the tensile, compression, shear and bending deformations of the metal specimen and to describe the changes in specimen profile up to the point of fracture
- Understand fatigue and specify the conditions under which it occurs
- Obtain from a fatigue plot for some material, the fatigue limit and fatigue strength
- Determine the steady-state creep rate and the rupture lifetime from a creep plot for some materials
- Understand unary and binary phase diagrams
- Determine the various phases present, composition and the mass fractions of the phases from a binary phase diagram
- Understand the relation between phase diagrams, microstructure and mechanical properties of materials
- Determine the heat treatment process required for an application
- Name different kinds of steels, cast irons and non-ferrous alloys, and for each cite distinctive properties and typical uses
- Understand the types and applications of ceramics and polymers
- Learn the different manufacturing processes for composite materials

Lab Component:

- To familiarise with the testing standards for mechanical characterisation
- To be able to identify different class of materials based on the stress-strain characteristics
- To distinguish between stiffness, hardness, toughness and resilience
- To assess the causes of error in evaluation of mechanical properties
- To understand the influence of heat treatment on hardness of materials
- To understand the preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process.
- To comprehend the 3D printing of polymer/metal/ceramic samples.

Course Outcomes

After undergoing this course students will be able to:

- Classify engineering materials based on their crystal structure

- Compute the material properties through testing of materials
- Interpret phase diagram for alloy preparation
- Relate the phase diagram, microstructure and the mechanical properties of materials
- Choose material for an application by analysing the requirements with the material properties
- Prepare polymer composites by hand lay-up, vacuum bagging, resin transfer moulding and filament winding processes

Theory component

I. Introduction and structure of solids **06 hrs**

Introduction to materials, Overview of Crystal Structure, Solid Solutions, Hume Rothery Rules,Crystal Imperfections, Critical nucleus size and Critical Free energy, Mechanism of Crystallization, Nucleation, Nucleation- Growth, Single crystal, Polycrystalline Materials, Basic principles of solidification of metals and alloys. Solidification time, Cooling curves, Non-crystalline solids,

II. Mechanical behaviour of materials and testing **06 hrs**

Testing of materials under tension, compression and shear loads, Hardness tests, fatigue and creep test. Impact testing, Fatigue testing, Fracture, Types, Fracture mechanics. Characteristics of creep curve & steady state creep. Fracture toughness & fatigue, Stress and temperature effects

III. Phase diagrams **06 hrs**

Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Phase Rule, Unary System, Binary Phase diagrams, Iron-carbon system. Phase transformations. Transformation rate effects and Isothermal transformations (TTT Curves), Continuous cooling transformations, Microstructure and property changes in iron-carbon system, Iron-carbon equilibrium diagram, Heat treatments.

IV Ferrous and non-ferrous metal alloys **05 hrs**

Classification of steels and cast iron, Microstructure, Effect of alloying elements on steel, Ferrous alloys and their applications, High Resistivity and High temperature alloys, Selection of material for various applications- case studies.

V Ceramics, polymers, composites and nanomaterials **05 hrs**

Ceramics, Glass Ceramics, Advanced ceramics, Functional properties and applications of ceramic materials and Glasses, Polymers, Composites, Nanomaterials, Materials used in additive manufacturing.

Lab component **28 hrs**

- Tension Test- To understand the tensile characteristics of mild steel through tensile testing and thereby determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area.

- Compression Test- To determine the compressive strength of aluminium and cast-iron specimens and to identify the failure modes of ductile/brittle materials through evaluation of their failure modes of above material.
- Shear Test - To determine ultimate shear strength of aluminium under single and double shear.
- Bending Test - To investigate the relationship between load and span on deflection of a simply supported beam subjected to a concentrated load at the centre. Also, evaluate the modulus of elasticity of the given beam from the test data.
- Impact Test (Charpy and Izod) - To evaluate the energy absorbed during failure of a notched specimen subjected to pendulum impact testing.
- Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens.
- Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen.
- Wear Test - To understand the parameters that affect the wear rate using pin and disc apparatus.
- Composite preparation- preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process
- Demonstration of 3D printing of given polymer/metal/ceramic specimens.

Industrial Visit- Report making

Text Book and References

Text books

1. William D. Callister, Jr., "Materials Science and Engineering an Introduction", 2nd Edition, John Wiley & Sons, Inc., 2007.
2. V. Raghavan, "Materials Science and Engineering", Prentice – Hall of India Pvt. Ltd., 2007
3. DSU Lab Manual

Reference books

1. J.M. Shackelford, Introduction to Materials Science for Engineers, 5th Edition, Prentice Hall, Inc. 2000.
2. Suryanarayana, A. V. K., Testing of Metallic Materials, Prentice Hall India, New Delhi, 1979.
3. W. Bolton, Engineering materials technology, 3rd Edition, Butterworth & Heinemann, 2001.
4. William F. Smith, Structure and Properties of Engineering Alloys, Mc-Graw-Hill Inc., U.S.A, 2nd edition, 1993

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 19ME2303
TITLE OF THE COURSE : ENGINEERING MECHANICS
L: T: P: S/P: C : 03:00:00:00:03

Course Objectives

The objectives of the Course are to:

- Explain different types of forces and couples, resolution of forces and couples, equilibrium conditions and related theorems
- Illustrate Couples and equivalent force couple system
- Illustrate principles of resolution and composition of forces
- Calculate moment of coplanar concurrent and coplanar non-concurrent forces
- Illustrate depicting free body diagrams of objects subjected to coplanar concurrent and non-concurrent force systems
- Explain concepts of friction and their relevance in Engineering problems
- Explain Limiting friction and Laws of Friction
- Illustrate wedge friction, ladder friction and related problems
- Describe centroid, center of gravity and differences between them, area moment of inertia, examples of planar objects and computations for them
- Calculate center of gravity/centroid for various planar figures
- Explain area moment of inertia and related theorems
- Explain mass moment of inertia and related theorems
- Determine area moment of inertia for various planar geometrical objects and composite sections
- Calculate Mass Moment of Inertia of simple non planar geometrical objects
- Describe Trusses and its classification, assumptions in analysis of trusses, forces in members in a truss
- Explain assumptions made in analysis of Trusses
- Describe various methods to analyze Planar Truss and nature of forces in members of Planar Truss
- Determine axial forces in members of Planar determinate Truss
- Illustrate rectilinear, plane curvilinear and projectile motions, velocity and acceleration of a particle in motion in a plane and in 3D
- Calculate various dynamic quantities of translational motion and projectile motion
- Explain principles of dynamics in plane motion analysis
- Illustrate D Alembert's principle and its applications in plane motion and connected bodies.

Course Outcomes

After undergoing this course students will be able to:

- Analyze structure using free body diagrams and principle of statics
- Analyze structures using concept of equilibrium conditions considering effect of frictional forces

- Calculate the centroid and moment of inertia of composite geometrical sections
- Compute axial forces in members of determinate truss
- Analyze plane kinematics and kinetics of particles/rigid bodies

Course Content

Introduction to Engineering Mechanics

Introduction to Engineering Mechanics, Force Systems Basic concepts, Particle Equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Resultant- Moment of Forces and its Application; Couples and Resultant of force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium.

Friction

Introduction, Types of friction, Limiting friction, Cone of Friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, Ladder friction, related problems.

Centroid, Centre and gravity and Moment of inertia

Introduction, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone.

Analysis of Trusses

Introduction, Classification of trusses, Equilibrium in two and three dimension; Method of Sections; Method of Joints; To determine if a member is in tension or compression; Simple Trusses; Zero force members.

Dynamics

Introduction, Rectilinear motion; Plane curvilinear motion (rectangular path, and polar coordinates); Projectile motion, Relative and constrained motion; Basic terms, general principles in dynamics; Types of motion, Instantaneous Centre of rotation in plane motion and simple problems; D Alembert's principle and its applications in plane motion and connected bodies.

Text Book and References

Text Book/s:

1. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall publications.
2. A Nelson (2009), Engineering Mechanics: Statics and dynamics, Tata McGraw Hill publications.

References:

3. F. P. Beer and E. R. Johnston (2011), Vector Mechanics for Engineers, Vol I - Statics, Vol II, – Dynamics, 9th Ed, Tata McGraw Hill publications.
4. R.C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
5. Bansal R.K.(2010), A Text Book of Engineering Mechanics, Laxmi Publications.
6. H.J. Sawant, S.P Nitsure(2018), Elements of Civil Engineering and Engineering Mechanics, Technical Publications.

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 19ME2304
TITLE OF THE COURSE : THERMODYNAMICS
L: T: P: S/P: C : 03:00:00:00:03

Course Objectives

The objectives of the Course are:

- To introduce basic concepts related to thermodynamic system and their classification like closed system, open system and isolated systems with examples
- To differentiate between Microscopic and Macroscopic thermodynamics
- To define terms like property, state, change of state, equation of state, path, process, cycle, thermodynamic equilibrium, quasi-static process, point and path function
- To state Zeroth law of thermodynamics and explain international practical temperature scale
- To understand work and heat interactions
- To understand first law of thermodynamics as applied to a closed system executing a cycle and executing a process
- To understand specific heat at constant volume and pressure, internal energy and enthalpy of a system
- To introduce perpetual motion machine of first kind
- To extend First law of thermodynamics to control volume and write down the expression for various devices like nozzle, turbine, heat exchanger etc.
- To understand working of heat engine and refrigeration cycles and to define the terms efficiency and Coefficient of Performance (COP)
- To state second law of thermodynamics: Kelvin Planck and Clausius Statement
- To introduce the concept of perpetual motion machine of second kind
- To explain reversible and irreversible processes
- To explain Carnot cycle and reversed heat engine-heat pump or refrigerator
- To define the property entropy through Clausis inequality
- To explain principle of Entropy generation
- To introduce the concept of Exergy, irreversibility and lost work
- To understand pure substance and to study thermodynamic property diagrams of pure substance
- To understand behaviour of ideal and real gases through equation of state and compressibility factor

Course Outcomes

After undergoing this course students will be able to:

- Explain the basic concepts of thermodynamics
- State zeroth law of thermodynamics, first law of thermodynamics as applied closed and open systems and develop and steady flow energy equation for various flow problems
- State second law of thermodynamics and explain the concept of entropy, principle of

increase of entropy, exergy and irreversibility

- Calculate work, heat, change of energy, change of entropy for closed and open system executing various thermodynamic processes with and without phase change
- Differentiate ideal and real gases and explain the compressibility factor
- Calculate gas constant, internal energy, enthalpy, specific heats and entropy for gases

Course Content

Basic Concepts of Thermodynamics

Introduction- Basic Concepts: System, Control Volume, Surrounding, Boundaries, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, Thermodynamic properties: definition and units. Intensive and extensive properties. Thermodynamic state, state point, path and process, quasi-static process, cyclic and non-cyclic processes, Energy and its forms, Work and heat (sign convention), Zeroth Law of Thermodynamics: Zeroth law of thermodynamics statement, Concept of Temperature and its' measurement, Temperature scales.

First Law of Thermodynamics

First law of thermodynamics-application to closed and open system, Joules experiments, equivalence of heat and work, Internal energy and enthalpy, energy as a property, specific heat at constant pressure and volume, PMM1, steady state, steady flow energy equation(SFEE), extension of first law to control volume, Limitations of first law of thermodynamics, Extension of SFEE to Various devices like-nozzle, turbine , pump/compressor, heat exchanger

Second Law of Thermodynamics

Thermal reservoirs, , devices converting work to heat in a thermodynamic cycle, heat engine, Efficiency reversed heat engine, heat pump, Refrigerator, Coefficient of Performance, Kelvin-Planck and Clausius statement of second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, factors that make a process irreversible, Carnot cycle and Carnot engine, Carnot theorem and its corollaries.

Entropy

Classius Inequality: Statement, proof, application to a reversible cycle, Entropy: Definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, Tds equation, calculation of entropy using TdS relations, entropy as a coordinate, Exergy(Available) and unavailable energy, Second law efficiency.

Ideal, Real gases and Pure substance

Ideal and Real Gases, Gas laws- Boyle's Law, Charles Law ,Gay-Lussac Law, Avogadro's law, equation of state - Vander Waals, Redlich-Kwong, Peng- Robinson etc. compressibility factor, Pure substance, Phase change process in a pure substance, Definition of triple, ice, steam and critical points, Property diagrams of pure substance, *p-v, p-T, p-h, T-v* diagrams, dryness fraction, use of steam tables.

Text Book and References

Text Book:

1 Thermodynamics (2018), Special Edition, McGraw Hill Education India Private Ltd, Chennai

References:

1 Van Wylen, G.J., and Sonnatag, R.E., (2002), Fundamentals of Classical Thermodynamics for Engineers, 6th Edition, Wiley

2 Francis F. Huang (1989), Engineering Thermodynamics, Maxwell Macmillan International Editions

3. Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, Chichester

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 19ME2305
TITLE OF THE COURSE : COMPUTER AIDED MACHINE DRAWING
L: T: P: S/P: C : 02:00:04:00:04

Course Objectives
The objectives of the Course is to:

- Provide overview of various CAD software
- Introduce wireframe, solid and surface modeling concepts
- Learn basics of sketching features
- Create 3D models using extrude, revolve, draft & other advanced options
- Learn using features like draft, fillet, chamfer, scale etc.
- Introduce assembly concepts
- Create simple & complex mechanical assemblies
- Review of 1st and 3rd angle projection
- Create industrial standard drawings with appropriate views including sectional views
- Appllication of symbols, BOM & tolerance
- Awareness of various data exchange standards and procedures

Course Outcomes
After undergoing this course, students will be able to:

- Discuss different types of CAD tools
- Create 2D geometric sketches by Autodesk FUSION 360.
- Develop 3D models of components using basic and advanced features
- Create different types of assemblies using appropriate constraints
- Produce BOM and manufacturing drawings using appropriate views, symbols & tolerances
- Discuss applications of CAD data exchange formats

Module-1: CAD overview
Preferences-Settings, User Interface- Familiarize the User Interface by creating a simple design, Use of toolbar, marking menu, browser and time line controls, change of workspace, Navigations and data panel interface, Design Units and Origin, Quick Shape Creation

Module-2: Sketching workspace
Creating a sketching geometries - Introduction to the Sketching Workflow, Sketch Entities, Dimensioning, Sketch Constraints. **Additional Sketching Tools-** Additional Entity Types, Editing Tools, Additional Dimension Tools, Moving and Copying, Rectangular and circular Patterns. **Sketched Secondary Features** using existing geometry. **Pick and Place Features-** Fillets, Chamfers, Holes, Editing Pick and Place Features. Construction of planes, axis and points, creating a sketch using Equation and Parameters

Module-3: Introduction to Solid Modeling
Introduction-Solid Modeling techniques: Constructive Solid Geometry using primitives, Boundary representation & Hybrid methods. **Basic Part modelling features-** Extrude and

revolve. **Additional Features and Operations**- Draft, Shell, Rib, Split Face, Scale, Thread, Press Pull. **Design and Display Manipulation-** Reordering, inserting, suppressing Features, Measure and Section Analysis, Direct Modeling Development of multi section solids and sweep. **Feature Duplication –** mirroring and patterning.
Develop the part models and prepare the drafting. List out the operations involved to prepare the components.

Module-4: Assembly and Generation of Manufacturing Drawings

Distributed Design- Assembly Design Methods, Joint Origins and Assigning Joints. **Component Design Tools**- Rigid Groups, Interference Detection. **Multi-Body Design**-Multi-Body Design Tools, Components, As-Built Joints.**Drawing Basics-**Creating a New Drawing, Additional Drawing Views, Exploded Views, Manipulating Drawings. **Detailing Drawings-** Dimensions, Parts List and Balloons, Annotation and Dimension Settings, Drawing Output. Data exchange standards – IGES, STP, STL, STEP etc.
Develop the assembly drawing from the given detailed drawing(Machine components upto five major parts). Indicate the empirical relations along with actual dimensions and bill of materials. Layout the drawings in A3 sheet.

Module-5: Assembly of Machine parts:
Develop the assembly drawing from the given detailed drawing showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly
1. Swivel bearing
2. Petrol engine connecting rod
3. Cylinder relief valve
4. Machine vice
5. Tailstock
6. Piston of a petrol engine
7. Air valve
8. Fuel Injector
9. Speed reducer
10. Drill jig

Layout the drawings in A1 sheet.

Text Book and References

Text Book:

1. K. R. Gopalakrishna, "Machine Drawing in First angle projection", Subhas publication, Bangalore, 2017.
2. N.D.Bhat & V.M.Panchal, "Machine Drawing", Charotar Publishing House, 1999.

References:

1. N. Siddeshwar, P. Kannaih & V.V.S. Sastri, "Machine Drawing", Tata Mc.Grawhill, 2006.
2. Basant Agrawal & C M Agrawal "Engineering Drawing, 2e", Mc.Grawhill, 2017

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 19ME2306
TITLE OF THE COURSE : MECHANICAL MEASUREMENTS
L: T: P: S/P: C : 03:00:02:00:04

Course Objectives

The objectives of the Course are to:

- Introduce the measurement quantities and measurement standards
- Learn the calibration and measurement processes
- Learn the types and applications of advanced metrology techniques like laser and CMM
- Study the limits, fits, tolerances and gauges
- Define the measurement of Temperature and strain
- Learn the concept of slip gauges and wringing phenomenon
- Study the different types of mechanical and electrical compactors
- Illustrate the linear and angular measurements
- Determine the primary detector-transducers, intermediate signal processing system and terminal systems

Lab Component:

- To provide the necessary skills for calibration and testing of different gauges and instruments.
- To cultivate safety aspects in handling of tools and equipment's.
- To provide the necessary skills to collect data, perform analysis and interpret results to draw valid conclusions through standard test procedures using various metrology instruments.

Course Outcomes

After undergoing this course students will be able to:

- Outcomes
- Explain measurement standards and system
- Calculate the uncertainty in measurements
- Explain tolerance, limits of size, fits, gauges and the various advancement in laser Interferometers, CMM, Machine Vision Systems
- Describe generalized measurement system highlighting various types of sensors, Identify transducers, signal conditioning components, and different types of presentation devices. measurement of temperature, pressure
- Calibrate various measuring devices and errors and correction factors of various measuring devices
- Compute the linear and angular measurements and demonstrate the necessary skills to collect data, perform analysis and interpret results to draw valid conclusions through standard test procedures.

Course Content

MODULE- 1

Standards of Measurement in Metrology:

Definition, objectives and concept of metrology, role of standards, standards of length Principles, light wave length standards, subdivision of standards, calibration of standards, numerical problems, slip gauges, set of gauges, wringing phenomena, manufacture of slip gauges. Numerical problems on building of slip gauges, **Comparators** - mechanical, electrical, pneumatic and optical comparators. **06- Hrs**

MODULE- 2

System of Limits, Fits, Tolerance and Gauging: Indian standards, concept of limits of size and tolerances, interchange ability, selective assembly definition of fits, hole basis system, shaft basis system, types of fits and their designation, geometric tolerance. Classification of gauges, brief concept of design of gauges (Taylor's principles),Numerical problems **Advances in Metrology** Basic concept of lasers Advantages of lasers, laser Interferometers. Basic concept of CMM, Types of CMM. **06- Hrs**

MODULE- 3

Measurement systems and its basic concepts:

Definition, significance of measurement, fundamental method of measurements, generalized measurement system, definitions and basic concepts, Linear Measurement and angular measurements. Errors in measuring instruments, classification of errors, sources of errors and uncertainty. **04-Hrs**

MODULE- 4

Introduction to transducers and intermediate modifying devices:

Introduction to Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers, **Intermediate modifying devices**: Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope **06- Hrs**

MODULE- 5

Temperature and Strain Measurements:

Temperature Measurement: Resistance thermometers, thermocouples, laws of thermocouple, materials used for construction, pyrometer, optical pyrometer, Strain Measurement: Theory of strain gauges, types, preparation and mounting of strain gauges, gauge factor, Temperature Compensation, Wheatstone bridge circuit.

06- Hrs

Lab Component:

1. **Calibration of Micrometer** - To calibrate the given micrometer using slip gauge, draw the calibration curve and to evaluate the errors occurred.
2. **Calibration of Vernier caliper and measurement of the given component** - To calibrate and measure the given component by using Vernier caliper.

3. **Calibration of Thermocouple** - To calibrate the given T-Type Thermocouple at different temperatures.
4. **Calibration of Linear Variable Differential Transformer (LVDT)** - To calibrate the given LVDT (for the performance using Vernier height gauge.
5. **Calibration of Load Cell** - To calibrate the given Cantilever Beam type load cell.
6. **Measurements using Optical Profile Projector** – To measure the screw thread parameters of a given specimen using Optical Profile projector.
7. **Measurements using Toolmaker's Microscope** - To measure the screw thread parameters of a given specimen using Tool Maker's Microscope.
8. **Measurements of angle using Sine bar** - To determine the unknown angle of the given specimen using sine bar with the help of slip gauge.
9. **Measurements of angle using universal bevel protractor** - To determine the unknown angle of the given specimen using universal bevel protractor.
10. **Measurements of Screw thread parameters using two wire or three-wire methods** - To find the effective diameter of a given screw thread by two or three wire method.
11. **Measurements of gear tooth profile using gear tooth Vernier caliper** - To Measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper.
12. **Measurements of Vibrations** - To study the vibrations measurement, frequency, displacement, velocity & acceleration.
13. **Machine tool alignment test on**

a) Lathe. b) Drilling machine. c) Milling machine. d) CNC milling.

Text books and References

Text Book/s:

1. Mechanical Measurements, Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.
2. Engineering Metrology R.K. Jain, Khanna Publishers, New Delhi, 2009.

References:

1. Engineering Metrology and Measurements, Bentley, Pearson Education, Bengaluru 2006.
2. Theory and Design for Mechanical Measurements, Richard S Figliola, Donald E Beasley, WILEY, III edition, India Publishers.

Lab Component:

Text Book

1. R. K. Jain, 'Engineering Metrology', Khanna Publishers, 1999.
2. J. F. W. Gayler and C.R. Shotbolt, 'Metrology for Engineers' Cassel London, 1964.

References

1. ASTME: Handbook of Industrial Metrology, Prentice Hall, 1972.
2. F. T. Farago, 'Handbook of Dimensional Measurements', 2nd Ed. Industrial Press Inc. 1982.

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 19ME2401
TITLE OF THE COURSE : APPLIED THERMODYNAMICS
L: T: P: S/P: C : 02:01:02:00:04

Course Objectives

The objectives of the Course are:

- To understand Gas power cycles like Otto, Diesel and Dual cycles and calculation of heat, work interactions and thermal efficiency
- To understand Brayton Cycle and calculation of heat, work interactions and cycle thermal efficiency
- To illustrate the improvement of thermal efficiency of Brayton Cycle by addition of regenerator, intercooler and re-heater
- To understand Vapour power cycles and calculation of heat, work interactions and thermal efficiency
- To understand the effect of inlet pressure and temperature on the performance of vapour power cycles
- To illustrate the enhancement of performance of vapour power cycles by retrofitting superheating ,reheating, regeneration and air preheating operating at higher pressures
- To appreciate Supercritical operation of vapour power cycles
- To understand the operation of combined cycle with toping gas turbine and bottoming steam cycle
- Explain the uses of compressed air
- Explain the working of a single stage and multistage compressor
- Calculate work done on compressor in single and multistage compression
- Calculate volumetric, isothermal and polytropic efficiencies of compressor
- Explain importance of intercooling and deduce condition for minimum work done
- To understand refrigeration cycle and calculation of COP
- To understand different types of refrigerants and to appreciate the use of eco-friendly refrigerants
- To understand psychrometric terms
- To understand different clean energy technologies like solar, biomass and wind
- To appreciate the use of cogeneration in process industries
- To study sensible and latent heat energy storage techniques
- To carry out tests to investigate the performance of internal combustion engines
- Find out fire and flash point of different combustion fuels
- To impart how to measure important performance parameters of experimental investigation on internal combustion engines

Course Outcomes

After undergoing this course students will be able to:

- Calculate work obtained, mean effective pressure and thermal efficiency for Otto, Diesel , Dual and Bryton cycles, Thermal efficiency of Basic, modified , reheat and regenerative Rankine cycles
- Calculate the work done and efficiency for single stage and multistage compressor
- Analyse different refrigeration and air-conditioning cycles , different clean energy technologies like solar, biomass and wind to generate power
- Explain cogeneration cycle to improve energy efficiency and also study different thermal energy storage techniques
- Estimate the properties of fuels and lubricants like flash and fire point, viscosity and calorific value.
- Predict I C engine performance parameters at different operating conditions and also to carry out heat balance

Course Content

Theory component:

Gas Power Cycles

Review of thermodynamics laws, Carnot, Otto, Diesel and Dual Cycles; simple Gas turbine cycle (Brayton cycle) and Modifications; Multistage compression with intercooling, Regeneration, reheat cycles practical gas turbine, cycles; Jet Propulsion cycles;

Vapour Power Cycles and Combined cycle power plants

Components of steam power plant ,Carnot vapour power cycles, limitation of Carnot cycle, Simple Rankine cycle; ,Effect of pressure and Temperature on performance of Rankine Cycle, 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, feed water heaters. Reheat Rankine cycle, Supercritical Rankine cycle, combined gas and vapour cycle power plants. Numerical

Reciprocating Compressors

Classification; work done in a single stage compressor; efficiency; p-v diagram for an actual compressor and diagram factor; multistage compressor; Multistage compressor with intercooler, Performance parameters for reciprocating compressors,

Refrigeration and Air conditioning

Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Vapour absorption refrigeration system. Psychrometric:

Nomenclature, Definition, use of Psychrometric chart, Introduction to air conditioning, different types of air-conditioning systems

Clean Energy Technologies:

Solar Radiation-Flat Plate and Concentrating Collectors–Solar direct Thermal Applications–Solar thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Biomass direct combustion–Biomass gasifiers–Biogas plants–Digesters–Ethanol production–Biodiesel –Cogeneration, Types of Wind Energy Systems Performance–Details of Wind Turbine Generator, Sensible and latent thermal energy storage techniques, Numericals

Lab Component

1. Determination of Flash point and Fire point of lubricating oil using Abel, Pensky and Marten's (closed) / Cleavland's (Open Cup) Apparatus.
2. Determination of Calorific value of solid, liquid and gaseous fuels.
3. Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
4. Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).
5. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A-F Ratio, heat balance sheet.

Text Book and References

Text Book:

1 V Kadambi, T R Seetaraman , K B Subramnya Kumar, Applications of Thermodynamics (2019), Wiley India Private Ltd, New Delhi,

2 Nag P K, Basics and applied thermodynamics, Second edition, Tata McGraw Hill, New Delhi -2017.

References:

1 Van Wylen, G.J., and Sonnatag, R.E., (2002), Fundamentals of Classical Thermodynamics for Engineers, 6th Edition, Wiley Publication

2 T D Eastop, A McConkey (2019), Applied Thermodynamics, Person Publication, Noida

3 Rai.G.D (2011), "Non- Conventional Energy Sources", Khanna Publishers, New Delhi.

4 Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, Chichester

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SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 19ME2402
TITLE OF THE COURSE : MECHANICS OF MATERIALS
L: T: P: S/P: C : 02:01:00:00:03

Course Objectives

The objectives of the Course are to:

- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Draw Stress strain diagram for brittle and ductile materials and compare them
- Describe shear stress and strain, Lateral strain, Poisson's ratio, Elastic constants and relations between them
- Calculate stresses and strains in composite sections due to mechanical and thermal loads
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circle for plane stress conditions
- Describe Hoop's stress, maximum shear stress, circumferential and longitudinal strains in thin cylinders and Lames equations for thick cylinders
- Explain type of beams, loads and reactions, shear forces and bending moments
- Draw shear force and bending moment diagrams in beams to estimate maximum shear forces and bending moment
- Estimate bending and shear stress distribution in rectangular, I and T section of beams
- Explain torsional moment of resistance, power transmission of straight and stepped shafts, twist in shaft sections
- Describe Euler's theory, Limitations of Euler's Formula and Rankine's Formula
- Explain strain energy due to axial, shear, bending, torsion and impact load
- Discuss Castigliano's theorem and their applications
- Explain theories of failure as applied to materials

Course Outcomes

After undergoing this course students will be able to:

- Calculate stress and strain for different geometries under different loading conditions
- Illustrate principal stresses, maximum shearing stress acting on a structural member using analytical and Mohr's circle method
- Calculate the stresses and strains associated with thin and thick cylindrical pressure vessels under axial and circumferential loads
- Construct shear force and bending moment diagrams for statically determinate beams
- Calculate the shear stress for bodies subjected to torsion and bending stresses for columns
- Discuss theories of failure as applied to materials

Course Content

Stress and Strain

Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them. Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change.

Analysis of Stress and Strain

Compound Stresses: Principal stresses and maximum shear stress, Planes of Principal stress and Maximum Shear stress, Normal stress on the planes of maximum shear stress, Mohr's circle for plane stress conditions.

Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, thin spherical Shell, thin cylinder with spherical ends. Thick cylinders: Lame's theory.

Shear Forces and Bending Moments

Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, Shear force and bending moments of cantilever, simply supported and overhanging beams subjected to concentrated loads and uniformly distributed constant / varying loads.

Stress in Beams: Bending Theory**,** Bending and shear stress distribution in rectangular, I and T section beams.

Torsion

Torsion: Circular shafts, Power Transmission, Torsion of tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections.

Columns: Euler's theory, Equivalent Length, Limitations of Euler's Formula, Rankines Formula

Strain Energy

Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load, Castigliano's theorem and their applications.

Theories of Failure: Introduction, maximum principal stress theory (Rankine's theory), Maximum shearing stress theory (Guest's and Tresca's theory), maximum principal strain theory (St. Venant's theory), Maximum Strain energy theory (Haigh's Theory) and Maximum Shear Strain Energy Theory (Mises' and Henkeys's Theory)

Text Book and References

Text Book:

1. Mechanics of Materials (2018), Special Edition for DSU, McGraw Hill Education (India) Private Ltd, Chennai

References:

1. Stephen Timoshenko, Strength of Materials part I & part II, D Van Nastrand Company, 3rd Edition
2. R C Hibbeler, Mechanics of Materials, Pearson, 9th Edition, 2014
3. R K Bansal, A Textbook of Strength of Materials, 4th Edition, Laxmi Publications, 2010
4. R K Rajput, Strength of Materials, S. Chand and Company Pvt. Ltd, 2014
5. S. S. Bhavikatti, Strength of Materials, Vikas publications House-Pvt. Ltd., 2nd Edition, 2006

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 19ME2403
TITLE OF THE COURSE : FLUID MECHANICS AND MACHINES
L: T: P: S/P: C : 03:00:02:00:04

Course Objectives

The objectives of the Course are:

- To review SI Units of various quantities used in Fluid Mechanics
- Describe basic concepts of Fluid Mechanics.
- Identify the various types of fluid flow problems encountered in practice.
- Define basic properties of fluids and understand the continuum approximation.
- Define viscosity and the consequences of the frictional effects it causes in fluid flow.
- Calculate the capillary rise (or drop) in tubes due to the surface tension effect.
- Determine the variation of pressure in a fluid at rest
- Calculate pressure using various kinds of manometers
- Define kinematics of Fluid Flow
- Describe Lagrangian and Eulerian Approach for fluid flow
- Describe Flow visualization.
- Plot flow data.
- Explain Fundamental kinematic properties of fluid motion and deformation
- Define kinematics of Fluid Flow
- Describe Lagrangian and Eulerian Approach for fluid flow
- Continuity equation
- Velocity and acceleration in a flow field
- Potential and stream function
- Bernoulli's equation
- Application of Bernoulli's equation
- Venturimeter, orifice meter, pitot tube
- Losses in pipe-major and minor losses
- Differentiate laminar and turbulent flow in pipes
- Analyze fully developed flow
- Describe flow rate measurement techniques and learn their advantages and disadvantages
- List dimensions, units, and dimensional homogeneity
- State benefits of dimensional analysis
- Buckingham's Pi theorem
- Explain the concept of similarity and how to apply it to experimentation.
- Identify various types of pumps and turbines and understand how they work
- Apply dimensional analysis to design new pumps or turbines that are geometrically similar to existing pumps or turbines
- Use specific speed for preliminary design and selection of pumps and turbines
- To perform experiments on flow measurements using different flow measuring devices

like Orifice meter, Venturimeter, Notches, Rotameter and also perform calculations related to losses in pipes.

- To study the performance parameters of Reciprocating , Centrifugal and Gear pumps
- To study the performance parameters of Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine and Kaplan turbine

Course Outcomes

After undergoing this course students will be able to:

- Define fluid, fluid properties and express fluid properties in terms of various measurable parameters
- Explain fluid dynamics and develop relevant fluid dynamic relations considering continuity, momentum and energy equations, apply the relations for analysis of dynamic forces and flow through various geometries
- Apply concepts of dimensional analysis to develop mathematical relations for various fluid flow situations
- Explain working principles of hydraulic turbomachinery and calculate the power and efficiencies involved in operations of machines and learn concepts of compressible flow
- Calculate flow rates of fluids using Orifice meter, Venturimeter, Notches, Rotameter, losses in pipe
- Study the performance parameters of Reciprocating , Centrifugal and Gear pumps, Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine

Course Content

Theory component:

Fluid Properties and Fluid Statics

Introduction, properties of fluids, viscosity, thermodynamics properties, surface tension and capillarity, vapour pressure. Types of fluid flows Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid,

Fluid Kinematics and Dynamics

Fluid Kinematics- Introduction, Lagrangian and Eulerian Approach for fluid flow, Continuity equation Velocity and acceleration in a flow field, Potential and stream function, Fluid Dynamics **-** Introduction, Equation of motion, Euler's equation of motion, and Bernoulli's equation derived from fundamental &Euler's equation, Bernoulli's equation for real fluids. Fluid Flow measurements-Venturimeter, orifice meter and Pitot tube. Flow through Pipes-Major & Minor losses in pipe flow. Numerical exercise

Dimensional Analysis and Boundary Layers

Introduction, Dimensional homogeneity –Buckingham theorem – Non-dimensional numbers – Model laws; Unit Quantities and Specific quantities, introduction to boundary layer theory –

Laminar flow and Turbulent flow – Boundary layer thickness

Hydraulic Turbines
Euler's Turbine equation,Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis and Kaplan turbine –work done and efficiencies. Draft tube theory, Performance of hydraulic machines, unit and specific quantities, turbine governing

Pumps
Classification, working, work done – monometric head- losses and efficiencies- specific speed-pumps in series and parallel-performance characteristic curves, NPSH. Reciprocating pumps: Working, Discharge, slip,

Lab component:

1. **Rotameter**
   Calculation of the Rate of Flow Using Rotameter
2. **Venturimeter**
   Determination of the Co- Efficient of Discharge of the Venturimeter
3. **Orifice Meter**
   Determination of the Co-Efficient of Discharge of the Given Orifice Meter
4. **Pipe Friction**
   Determination of frictional loss in a pipe flow
5. **Pipe Fittings**
   Determination of Loss of Head on Pipe Fittings
6. **Notch**
   Determination of Co- efficient of Discharge of the Given Notch
7. **Centrifugal Pump**
   Study of Performance Test On Centrifugal Pump
8. **Reciprocating Pump**
   Study of Performance Test On Reciprocating Pump
9. **Gear Pump Test Rig**
   Study of Performance Test On Gear Pump
10. **Pelton Wheel Turbine**
    Study of Performance Test on Pelton Wheel Turbine
11. **Francis Turbine**
    Study of Performance Characteristics Curves of Francis Turbine

Text Book and References

Text Book:

- Fluid Mechanics and Machines (2018), DSU Special Edition, McGraw Hill Education India Private Ltd, Chennai

References:

1. Yunus A.Cengel, John M.Cimbala (2006),"Fluid Mechanics – Fundamental and Applications", Tata McGraw-Hill Publishing Co. Ltd.
2. Frank M White (2011), "Fluid Mechanics" (In SI units), McGraw-Hill Publication, Seventh Edition
3. DSU lab Manual

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 19ME2404
TITLE OF THE COURSE : MANUFACTURING PROCESS
L: T: P: S/P: C : 03:00:02:00:04

Course Objectives

Theory component:

The objectives of the Course are:

- To emphasize the importance of manufacturing sciences in the day-to-day life, and to study the basic manufacturing processes.
- To develop a practice of continuously updating with latest knowledge and information in manufacturing process
- To have a broad knowledge on casting process for a given product.
- To understand the importance of metal forming process.
- To understand basic manufacturing processes like casting and welding process.
- To introduce the concepts of powder metallurgy in manufacturing process.
- To provide knowledge on characteristics and testing of metal powders.
- To impart sound knowledge and processing of plastic components.
- To identify, discuss, and analyse the manufacturing processes for processing of plastics.

Lab Component:

- To impart knowledge and skills to use tools, machines, equipment, and measuring instruments
- To provide knowledge of various casting process in manufacturing.
- To impart knowledge of joining process used in manufacturing.

Course Outcomes

After undergoing this course, students will be able to:

- Explain significance and engineering applications of various casting processes
- Interpret foundry practices like pattern, mold and core making required for Casting process
- Differentiate various metal forming processes such as Hot and Cold Working, Rolling, Forging, Extrusion and Drawing Processes
- Choose appropriate joining processes for a given application
- Construct different types components using casting, welding and smithy shop
- Explain working principle and engineering applications of various manufacturing processes.

Course Content

CASTING PROCESS 05 hrs

Casting- Introduction, Advantages and applications; Principle of casting processes – Sand casting, Centrifugal casting, pressure die casting, Investment casting, stir casting, solidification of casting, Gating-Principles, requirements and types, Riser – Function, types, design, Defects in castings. Patterns – Types, making, materials and allowances.

METAL FORMING **06 hrs**

Hot working & cold working, plastic deformation, yield criteria, strain hardening, recovery, recrystallization and grain growth. Rolling types & process, drawing types, sheet forming types & process, Extrusion process types, Forging Processes- classification & types- Power forging, Impression die forging, press forging, upset forging, defects in forging.

WELDING PROCESS **06 hrs**

Welding process: Classification, morphology of fusion weld, working principle, Fusion welding: Arc welding- Gas metal arc welding (MIG), Gas Tungsten arc welding (TIG), shielded metal arc welding (SMAW), plasma arc welding, oxyfuel gas welding, Resistance welding- spot, seam, projection, Solid state welding: Friction, friction stir welding, ultrasonic welding, forge welding, electromagnetic pulse welding, hot isostatic pressure welding, Laser welding, Electron beam welding, thermit welding.

POWDER METALLURGY **06 hrs**

Introduction & applications, basic steps, methods of manufacturing powders- Physical, Chemical, Mechanical & Nano powder production methods, mixing of powders, compaction- Pressure less and pressure compaction, explosive compaction, sintering methods, post sintering process, Defects in Powder metallurgy, Characteristics and testing of Metal Powders.

PROCESSING OF PLASTICS **05 hrs**

Classification of Polymers, Forms of raw plastic material, Types and characteristics of plastics**,** methods of processing plastics, moulding of thermoplastics – working principles and applications, compression moulding, Transfer Moulding, blow moulding, rotational moulding, Film blowing, Thermoforming.

Lab Component: Industrial visit

Text Book and References

Text Book:

1. Bergman M. “Manufacturing Processes”, Texas Publication, 1st Edition, 1956.
2. Kalpakjian S., Schmid S.R. “Manufacturing Engineering & Technology”, Pearson Edu Asia, 4th Edition, 2000.
3. Ghosh A., Malik A.K. “Manufacturing Science”, Affiliated East-West Press Ltd, 1st Edition, 2001.
4. Rao P.N. “Manufacturing Technology: Metal cutting & Machine Tools”, McGraw Hill Publication, 3rd Edition 2013.
5. Angelo P.C. and R.Subramanian., “Powder Metallurgy: Science, Technology and Application” Prentice Hall, 2008

References:

1. Mikell P. Groover, “Fundamentals of Modern Manufacturing”, John Wiley & Sons, Inc, New Jersey, 2010.
2. De Garmo, Black, and Kohser “Materials and Processes in Manufacturing”, John Wiley & Sons, Inc, New York, 2011.
3. Heine R., Loper C. and Rosenthal P., “Principles of Metal Casting”, Tata Mc Graw Hill Publishing Co. Ltd., New Delhi, 2001.

4. Parmer R.S., “Welding Processes & Technology”, Khanna Publishers, 2001
5. Rosatao, D.V., “Blow Moulding Handbook, Hanser publisher, 1989
6. Pye R G W., “Injection Mould Design : An Introduction And Design For The Thermoplastics Industry”, Longman; 4th Revised edition edition,1989

Lab Component:
Simple Exercises

1. **Foundry shop:** Tensile Strength Test for Core Sand, Compression Test of Molding Sand, Shear Test of Moulding Sand Permeability Test, Grain Fineness Test, Clay Content Test, Moisture Content Test, Mould Hardness Test, Industrial Visit
2. **Smithy shop**: Simple exercises involving the fabrication of square & hexagonal bolts.
3. **Welding shop**: Gas welding & Arc Welding
4. **Powder Metallurgy**- To perform powder compaction of different metal powder by hydraulic press & study the mechanism of sintering (Demo)
   Industrial Visit- Report making

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 19ENC003
TITLE OF THE COURSE : ECONOMICS FOR ENGINEERS
L: T: P: S/P: C : 02:00:00:00:02

Course Objectives

The objectives of the Course are to:

- Understand the importance of economics in engineering decisions as well as day-to-day life and identify various factors of production
- Determine production possibility curve, marginal rate of transformation and opportunity costs
- Calculate compound interest, effective interest, nominal interest and the inflation value
- Draw the cash-flow diagram of a firm, calculate their present worth and equivalent annual worth
- Describe methods to compare assets of equal and unequal lives and understand sinking fund method
- Discuss capital budgeting, payback period method, account rate of return method, benefit/cost analysis
- Discuss net present value method, internal rate of return and return on investment
- Explain replacement criteria such as deterioration, obsolescence, inadequacy and cyclic replacements
- Explain the causes, methods of computing depreciation values, and relation with Indian Income Tax act
- Calculate depreciation using various methods
- Discuss break-even analysis

Course Outcomes

After undergoing this course students will be able to:

- Explain the relevance of economics in engineering manufacturing environment.
- Determine the time value of money
- Determine the present worth and equivalent annual worth of the firm's assets and investments.
- Assess the available economic alternatives using traditional and discounted cash flow methods
- Calculate the depreciation value of equipment using different methods
- Perform break-even analysis for a manufacturing company

Course Content

Basic Concepts of Engineering Economics 04 hours

Introduction to Engineering economics, Engineering decision makers, engineering and economics, problem solving and decision making, strategy and tactics, factors of production, Production possibility schedule and curve, marginal rate of transformation, Concept of economic growth

Time Value of Money **03 hours**

Time value of money - Simple interest, compound interest – nominal interest rate, effective interest rate, and inflation.

Present Worth and Equivalent Annual-Worth Comparisons **07 hours**

Present worth calculations, Equivalent Annual worth Comparison methods, Situations for Equivalent Annual worth Comparison, Consideration of asset life, comparison of assets with equal and unequal lives,

Economic Evaluations **07 hours**

Introduction, capital budgeting, importance of capital budgeting, Traditional and discounted cash flow methods of capital budgeting – payback period method, accounting rate of return method, profitability index, net present value method, internal rate of return, Benefit/Cost Analysis, return on investment. break-even analysis

Replacement Analysis and Depreciation **05 hours**

Replacement due to deterioration, obsolescence, inadequacy, Economic life for cyclic replacements,

Depreciation, Causes of Depreciation, Basic methods of computing depreciation charges, Use of sinking fund method.

Text Book and References

Text Book:

1 Riggs, J., Bedworth D., & Randhawa S., (2011), **Engineering Economics,** 4th Edition, McGraw-Hill Education

2 Pindyck, R. S., & Rubinfeld, D. L. (2015), **Microeconomics,** 7th edition, Pearson Education India

References:

- Panneerselvam R, (2013), **Engineering Economics,** 2nd edition, Prentice Hall India Learning Private Limited

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3501**					
TITLE OF THE COURSE	**Heat Transfer (Theory & Practice)**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**2**	**-**	**70**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III	19ME2304	Thermodynamics

COURSE OBJECTIVES :

- To understand the basic phenomenon of heat transfer and its importance in engineering applications.
- To enable the students to understand the different modes of heat transfer like conduction, convection and radiation.
- To understand the mechanism of heat transfer under steady and transient conditions
- To illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation
- To understand the different laws of radiation and applying for solving engineering problems

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction	L3
CO2	Calculate forced and free convective heat transfer coefficient and rate of heat transfer	L3
CO3	Analyze performance characteristics of heat exchangers	L4
CO4	Calculate radiation heat transfer between objects with simple geometries	L3
CO5	Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	L2

COURSE CONTENT:	
MODULE 1	**08 Hrs**
Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional	

conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems.
MODULE 2 **08 Hrs**
Introduction, Heat transfer through rectangular fin, infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. Transient Conduction: Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems
MODULE 3 **10 Hrs**
Natural Convection: Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. Forced Convection: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems.
MODULE 4 **08 Hrs**
Fundamental concepts of radiation, different laws governing radiation heat transfer, Stefan-Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse gray surfaces, radiation shields, numerical problems.
MODULE 5 **08 Hrs**
Heat exchangers: Classification and applications, overall heat transfer coefficient, heat exchanger analysis–Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness–number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. Condensation and Boiling: Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems).

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Determination of thermal conductivity of metal rod.
2.	Determination of thermal conductivity of composite wall.
3.	Experiment on transient conduction heat transfer.
4.	Determination of heat transfer coefficient in natural convection.
5.	Determination of heat transfer coefficient in forced convection.

6.	Determination of temperature distribution, fin efficiency in natural / forced Convection.
7.	Determination of emissivity of a test surface.
8.	Determination of the emissive power of black body using Stefan's Boltzmann's constant.
9.	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger.

TEXT BOOKS :

1. Incropera, F.P. and DeWitt, D.P(2011). "Fundamentals of Heat and Mass transfer , John Wiley

REFERENCES :

1. Ozisik(2002.), Heat Transfer-A Basic Approach, Tata Mc Graw Hill.
2. P K Nag (2011), Heat and Mass Transfer, Tata McGrawHill
3. J P Holaman (2009), Heat Transfer, Tata McGrawHill.
4. C.P. Kothandraman, S. Subramanyan(2014), Heat and Mass Transfer Data Book, New Age International Publishers,

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3502**					
TITLE OF THE COURSE	**Kinematics and Theory of Machines**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**1**	**--**	**-**	**56**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

- To impart knowledge on the kinematics and dynamics of planar mechanisms
- analyze the bodies which is in motion using the basics of kinetics and kinematics
- To determine the balancing of masses of rotating and reciprocating machine elements
- To understand the principles of cams, governors and gyroscope
- To familiarize various mechanism by modeling and simulating the final motion in 3D modeling software
- To be able to make completely balanced systems by identify the angular position and spacing between each masses
- To distinguish the performance of different governors by characterize effort, power and sensitiveness
- To understand the gyroscopic principle and verifying its effect by changing the torque

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Discuss the fundamentals of various mechanisms and its inversion	L2
CO2	Perform velocity and acceleration analysis of a particle in a given system and angular velocity of rigid bodies that are in plane motion.	L3
CO3	Solve the problems related to balancing the parts in rotating and reciprocating systems	L3
CO4	Apply the principles of balancing of masses to various systems and engines	L3
CO5	Construct the cam profile for a desired motion. Recognize the fundamentals of governor and gyroscope	L3

COURSE CONTENT:	
MODULE 1	**12Hrs**
Definitions Link or element, kinematic pairs, chain, Mechanism and Structure, Degrees of freedom, Grubler's criterion. Inversions of various mechanisms. Quick return motion Mechanisms. Straight line motion mechanisms. Intermittent Motion mechanisms. Toggle mechanism, Pantograph, Steering gears mechanism. Universal Hooke's Joint.	
MODULE 2	**12Hrs**
Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism. Relative velocity and acceleration of particles in a common link and coincident Particles on separate links- Coriolis component of acceleration. Velocity Analysis by Instantaneous Center Method. Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.	
MODULE 3	**12Hrs**
Introduction, Static equilibrium. Equilibrium of two and three force members, members with two forces and torque, free body diagrams. Principle of virtual work, static force analysis of various mechanisms with and without friction. Dynamic Force Analysis: D'Alembert's principle, inertia force and torque. Dynamic force analysis of four-bar and slider crank mechanism.	
MODULE 4	**10Hrs**
Static and dynamic balancing. Balancing of single and several rotating mass. Balancing of single cylinder engine: multi cylinder-inline engine (primary & secondary forces), V-type engine. Balancing of locomotives	
MODULE 5	**10Hrs**
Types of cams and followers. Development of cam profile for various types of follower and its different motion. Governors: Types of governors; governor characteristics, force analysis of centrifugal governors. Gyroscope: Vector representation of angular motion. Gyroscopic couple, effect of gyroscopic couple on ship, plane disc, aeroplane,	

TEXT BOOKS :

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi,

REFERENCES :

1. Theory of Machines & Mechanisms, J.J. Uicker, G.R. Pennock, J.E. Shigley. Oxford University Press, 4th Edition, 2010.
2. Theory of Machines, Thomas Bevan, CBS Publication 3rd Edition, 2005.
3. Theory of Mechanisms and Machines: Amitabha Ghosh and Ashok kumar Mallik, 3rd Edition Affiliated East-West Press.1976.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3503**					
TITLE OF THE COURSE	**Design of Machine Elements-1**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**1**	**2**	**-**	**70**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV/II	19ME2402	Mechanics of Materials

COURSE OBJECTIVES :

- Understand the stresses in machine members due to various types of loads and failure of components according to theories of failures.
- Analyze the components under variable loading for infinite and finite life.
- Design of machine elements under torsion, bending, axial loads and a combination of these.
- Design of permanent and temporary joints and fasteners for a given load to be transmitted.
- Design of various screws, keys, coupling and shafts.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Classify various stresses acting on a machine element	L2
CO2	Compute the dimensions of component based on the concepts of failure theories	L3
CO3	Interpret different kinds of loading in mechanical engineering components	L3
CO4	Quantify factor of safety, failure modes for mechanical components subjected to direct and bending and combined loading	L3
CO5	Choose the appropriate keys, coupling, shafts and joints in the design of machine components	L2

COURSE CONTENT:	
MODULE 1	**10Hrs**

Normal, shear, biaxial and triaxial stresses, stress tensor, principal stresses. Stress-strain diagrams, stress analysis. Design considerations: Codes and standards, design stress, factor of safety, stress concentration factor in tension, bending and torsion, theories of failures, Static Strength: Static loads, Impact Strength: Introduction, impact

stresses due to axial, bending and torsional loads, effect of inertia, Failure of brittle and ductile materials	
MODULE 2	**08Hrs**
Introduction, S-N Diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.	
MODULE 3	**08Hrs**
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. Riveted and Welded Joints: Types, rivet materials, failures of riveted joints, joint efficiency, boiler joints, riveted brackets. Welded Joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints.	
MODULE 4	**08Hrs**
Joints: Types of keys, design of socket-spigot cotter joint, design of knuckle joint. Couplings: Types of couplings, design of flange and flexible couplings and muff coupling	
MODULE 5	**08Hrs**
Shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads. Curved Beams: Stresses in curved beams of standard cross sections used in crane hook	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs	
1.	Determination of principal stresses and strains in a member subjected to combined loading using strain rosettes and verification using FEA tool.
2.	Determination of critical speed of a rotating shaft and verification using FEA tool.
3.	Determination of stresses in curved beam using strain gauge and verification using FEA tool.
4.	Design of Shafts subjected to direct and combined loading for given loads and conditions and comparing design by using CAD/CAE software.
5.	Determination of Fringe constant of Photo-elastic material using. a) Circular disc subjected to diametric compression. B) Pure bending specimen (four point bending)

TEXT BOOKS :

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.

2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

REFERENCES :

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh, Design of Machine Elements Pearson Education, Eighth edition 2019.
3. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.
4. R S Khurmi and J K Gupta, A Textbook on Machine Design, S Chand Publications, Fourteenth Edition 2005.
5. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
6. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19EME3504**					
TITLE OF THE COURSE	**Manufacturing Technology**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**2**	**-**	**70**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1.	IV/II	19ME2404	Manufacturing Process

COURSE OBJECTIVES :

- To understand the basic fundamentals and mechanics of metal cutting, tool geometry and life.
- To know the basic knowledge of various machine tools, classification, specification, operations of each machining process like turning, milling, drilling, shaping and grinding operations.
- To impart knowledge on Non-Traditional & CNC machining operation
- To understand the fundamentals of various additive manufacturing technologies for application to various industrial needs

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Choose appropriate machine tools for various machining operations	L3
CO2	Identify traditional machining processes for turning, milling, drilling and grinding operations	L3
CO3	Classify non-traditional machining processes for advanced machining applications	L2
CO4	Analyse working features of CNC machines and part programming	L3
CO5	Describe the methods for manufacture of products using 3D Printing technologies	L2

COURSE CONTENT:	
MODULE 1	**08Hrs**
Types of cutting tool materials, cutting fluids, Single & Multi point cutting tool nomenclature, orthogonal and oblique cutting, mechanism of chip formation, types of chip, merchant analysis, Ernst-merchant's solution, shear angle relationship, problem of merchant's analysis, tool wear and tool failure effects of cutting parameters, tool life criteria, Taylor's tool life equation, problems.	

MODULE 2	**08Hrs**
Lathe Machine: Classification, features, driving mechanisms of lathe and operations on lathe. Drilling machine: Classification, features & operations. Milling: Classification, features, operations, up and down milling, Indexing concepts. Grinding: Types of abrasives, bonding process, structure & types of grinding wheels	
MODULE 3	**10Hrs**
Introduction, Classification, Abrasive jet machining, Ultrasonic machining, Water jet machining, Abrasive Water Jet Machining, Electro chemical machining, Electro Chemical Grinding, Electro-discharge machining, Laser beam machining, Electron Beam Machining, Chemical Milling, Photochemical Milling process characteristics – applications, advantages and disadvantages.	
MODULE 4	**08Hrs**
Fundamentals of numerical control, advantages & classification of NC systems, Functions of MCU, principles of operation features, functions of CNC, Manual part programming, Codes and concepts, point to point and contour programming examples, 2-D simple problems of Drilling, Turning and Milling.	
MODULE 5	**08Hrs**
Introduction, Prototyping fundamentals, Classification, applications, 3D modeling, Data Conversion and transmission, Post processing, RP data formats, Introduction on liquid, solid and powder based additive manufacturing systems, Case studies.	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs	
1.	To Study of Mechanism in Lathe and Perform Various Operations on a Lathe Machine.
2.	To study tool wear and tool life measurements for machinability
3.	To Study Construction, Working and Performing Operations on a Drilling & Grinding Machine.
4.	To Study Construction and Working of Milling Machine
5.	To Study Construction, Working and Perform of Shaping Operation on a Shaper Machine.
6.	Introduction of Computer Numerical Control Machines and working of few Models on CNC machine.
7.	Study the mechanism and working of 3D Printing machine.

TEXT BOOKS :

1. Serope Kalpak Jain and Steven R. Schmid, "Manufacturing Engineering and Technology", 7th Edition, Prentice Hall, 2018.

2. P.N. Rao, “Manufacturing Technology – Metal Cutting and Machine Tools,”Volume-II,4 Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2018.

REFERENCES :

1. M. P. Groover, “Fundamentals of Modern manufacturing” -materials, processes and systems Third Edition, Wiley publications, 7th Edition, 2019.
2. Kaushik Kumar, Chikesh Ranjan and Paulo Davim, CNC Programming for Machining, Springer International Publishing, 2020.
3. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies-3D printing, rapid prototyping, direct digital manufacturing”, Springer International Publishing, 2019.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19EME3505**					
TITLE OF THE COURSE	**Special Topics - III**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	**1**	**2**	**-**	**42**	**2**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

- Student should be able to solve problems in core and intra/inter/multidisciplinary areas
- Student should be aware with current technologies
- Developing critical and creative thinking.
- Work in team environment to develop communication skills

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Define problems in core and interdisciplinary and multidisciplinary areas	L2
CO2	Solve the subjective problem using current technologies	L3
CO3	Demonstrate the interdisciplinary/multidisciplinary approach.	L4
CO4	Prepare documentation for the solution.	L3

COURSE CONTENT:	
MODULE 1	**12Hrs**
Introduction to Python Programming and solving subjective problems.	
MODULE 2	**10Hrs**
Project under the guidance of faculty members on current semester subjects.	
MODULE 3	**10Hrs**
Solving subjective problem using software tools (Ansys, Catia, fusion 360)	
MODULE 4	**10Hrs**
Seminar on projects undertaken.	

PROFESSIONAL ELECTIVE – I

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3506**					
TITLE OF THE COURSE	**REFRIGERATION AND AIR CONDITIONING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV	19ME2401	APPLIED THERMODYNAMICS

COURSE OBJECTIVES :

- Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
- Discuss classification and properties of refrigerants
- Describe the Vapour compression and Vapour absorption systems
- Understand psychrometric properties and processes
- Study Air conditioning systems and air conditioning loads
- Understand the measuring instruments and sensors used in air conditioning

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain different methods of refrigeration	L2
CO2	Select the suitable refrigerant based on application and environmental consideration	L3
CO3	Analyse Vapour compression and Vapour absorption refrigeration systems	L4
CO4	Apply the knowledge of psychrometric properties and processes for air conditioning	L3
CO5	Compute air conditioning loads and Interpret air conditioning methods	L3

COURSE CONTENT:	
MODULE 1	**08Hrs**
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	

MODULE 2	**08Hrs**
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
MODULE 3	**10Hrs**
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li-Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
MODULE 4	**08Hrs**
Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	
MODULE 5	**08Hrs**
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

TEXT BOOKS :

1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill, 2008.
2 Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983.

REFERENCES :

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Domkundwar, V.M (2014), Refrigeration and Air-Conditioning Data Book, Dhapapatrai

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3507**					
TITLE OF THE COURSE	**QUALITY AND RELIABILITY ENGINEERING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

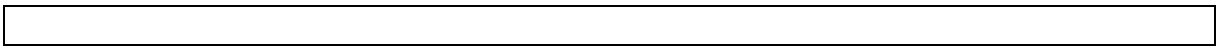
COURSE OBJECTIVES :

- To introduce the concepts of Statistical Quality Control.
- To understand process control and acceptance sampling procedure and their application.
- To learn the concept of reliability.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Apply tools and techniques of Total Quality Management	L3
CO2	Discuss Design Of Experiments, JIT and Total Productive Maintenance concepts in manufacturing	L2
CO3	Explain use of contemporary trends in Quality Management	L2
CO4	Analyze failure data using reliability concepts	L4
CO5	Describe use and implementation of international standards	L2

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction: Quality – Concept, Different Definitions and Dimensions, Inspection, Quality Control, Quality Assurance and Quality Management, Quality as Wining Strategy, Views of different Quality Gurus. **Total Quality Management TQM:** Introduction, Definitions and Principles of Operation, Tools and Techniques, such as, Quality Circles, 5 S Practice, Total Quality Control (TQC), Total Employee Involvement (TEI), Problem Solving Process, Quality Function Deployment (QFD), Failure Mode and Effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka-Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools, TQM Implementation and Limitations.	



MODULE 2	08Hrs
Introduction to Design of Experiments: Introduction, Methods, Taguchi approach, Achieving robust design, Steps in experimental design. Just –In –Time: Introduction to JIT production system, KANBAN system, JIT and Quality Production. Introduction to Total Productive Maintenance (TPM): Introduction, Content, Methods and Advantages Case Studies.	
MODULE 3	**08Hrs**
Contemporary Trends: Concurrent Engineering, Lean Manufacturing, Agile Manufacturing, World Class Manufacturing, Cost of Quality (COQ) system, Bench Marking, Business Process Re-engineering, Six Sigma - Basic Concept, Principle, Methodology, Implementation, Scope, Advantages and Limitation of all as applicable, Case studies.	
MODULE 4	**08Hrs**
Reliability Concepts: Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period; Useful life and wear out phase of a system; Mean time to failure (MTTF); Mean time between failure, (MTBF) and mean time to repair (MTTR); Reliability in terms of Hazard rate and failure density, Conditional probability and multiplication rules and related case studies.	
MODULE 5	**08Hrs**
Introduction to ISO 9000, ISO 14000 and QS 9000: Basic Concepts, Scope, Implementation, Benefits, Implantation Barriers.	

TEXT BOOKS :

1. Quality Assurance and Reliability Engineering" by Michelle Vine, Clanrye International, 2015
2 Jiang, Renyan" Introduction to Quality and Reliability Engineering", Springer, DOI:10.1007/978-3-662-47215-6,2015.

REFERENCES :

1. Total Quality Management by K C Arora, S K Kataria& Sons 8. Statistical Quality Control by Eugene L. Grant and Richard S. Leavenworth, McGraw-Hill Publishing Company Ltd.2013
2. The Basics of Reliability (Basics (Productivity))" by Ronald Blank, CRC Press, 2004

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3508**					
TITLE OF THE COURSE	**NON-DESTRUCTIVE EVALUATION AND TESTING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES :

- To impart knowledge to students in the latest technological topics on NDT.
- To provide them with opportunities in taking up advanced topics in the field of NDT.
- To appreciate the use of Non Destructive Testing (NDT) in evaluating the defects in mechanical components.
- To know the applications of NDT and recent trends

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify different NDT methods for various applications.	L4
CO2	Explain liquid penetrant testing and eddy current testing principles, advantages and their limitations	L2
CO3	Discuss and magnetic particle testing procedures and their applications	L2
CO4	Describe Ultrasonic and Radiographic testing principles, advantages and their applications	L2

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction to NDT, scope and advantages, Classification of NDT, Selection of ND methods, Visual inspection, Equipment used for visual inspection. Introduction to Liquid Penetrant Evaluation Testing, principle, equipment, procedures, characteristics of penetrants, Liquid penetration inspection, evaluation, hazards, precautions, applications, advantages and limitation.	
MODULE 2	**08Hrs**
Eddy current Testing: Principles, advantages, disadvantages, eddy current response, material conductivity permeability, frequency, geometry, proximity, types of probes, typical applications and limitations.	

MODULE 3	**08Hrs**
Magnetic particle: Principle of magnetic particle testing, Methods to generate magnetic fields, magnetic particle testing equipment, types of magnetic particles, testing procedures, method of demagnetization, magnetic particle medium, evaluation of indications and acceptance standards, magnetic particle test, application, advantages and limitations.	
MODULE 4	**08Hrs**
Basic equipment characteristics of ultrasonic waves, variables inspection, inspection methods pulse echo A,B,C scans transmission, resonance techniques, transducer elements couplets, search units, contact types and immersion types inspection standards ,standard reference blocks.	
MODULE 5	**08Hrs**
X-ray radiography principle, equipment and methodology, Radiography image quality indicators, radiographic techniques, radiographic testing procedures, radiation source X rays and gamma rays, X-ray-tube, radio graphic films, neutron radiography, Thermal inspection principles, equipment inspection methods applications.	

TEXT BOOKS :

1. J Prasad, C.G.K. Nair, Non Destructive Testing and Evaluation of Materials, Tata MC Graw Hill.

REFERENCES :

1. Bray, Don E, and Stanley Roderick K, Non destructive evualtion -A tool in design manufacturing and service, revised, CRC Press, New York, 1997.
2. Davis H.E Troxel G.E Wiskovil C.T,The Testing instruction of Engineering materials, McGraw hill, 1998.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3509**					
TITLE OF THE COURSE	**TOOL DESIGN**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES :

- To understand the various types of tooling materials and their industrial applications.
- To develop capability to design and select single point and multipoint cutting tools for various machining operations.
- Exposure to variety of locating and clamping methods available.
- To enable the students to design jigs and fixtures for simple components
- To expose the students to the design/selection procedure of sheet metal and injection mold

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Select appropriate cutting tools required for producing a component.	L2
CO2	Apply design concepts of single point and multi-point cutting tools	L3
CO3	Demonstrate knowledge of various press tools and sheet tool operations.	L2
CO4	Classify and explain various types of injection moulding dies.	L4
CO5	Analyze and design a jig/fixture for a given simple component	L4

COURSE CONTENT:	
MODULE 1	**08Hrs**
Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	

MODULE 2	**08Hrs**
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies	
MODULE 3	**10Hrs**
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies	
MODULE 4	**08Hrs**
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies	
MODULE 5	**08Hrs**
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. Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.	

TEXT BOOKS :

1. Donaldson. C, Lecain.G.H and Goold.V.C, Tool Design, Tata McGraw Hill publishing company limited, New Delhi, 2002.

REFERENCES :

1. Surendra Kenav and Umesh Chandra, Production Engineering Design (Tool Design), New Delhi, 1994.
2. Mehtha.N.K, Machine Tool Design and Numerical Control, Tata Mc-Graw Hill, Third Edition, 2012.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19ME3510**					
TITLE OF THE COURSE	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**--**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES :

- Define machine learning and understand the basic theory underlying machine learning.
- Differentiate supervised, unsupervised and reinforcement learning.
- To present the fundamental principles and practices of AI and ML to address the real-world mechanical engineering problems.
- The course is designed to develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI
- Design and implement a typical AI problem to be solved Using Machine Learning Techniques

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Hand-on experience on Python Programming	L2
CO2	Demonstrate the representation of knowledge and reasoning	L2
CO3	Comprehend the ideas of AI and problem-solving techniques	L3
CO4	Realize Machine Learning techniques in supervised and unsupervised learning	L3
CO5	Recognize the importance of data science, AI & ML in Mechanical Engineering	L3

COURSE CONTENT:	
MODULE 1	**08Hrs**
Introduction, Basics: Basic types, variables, Decision making and Loops, Strings, Data Structures: Lists, Tuples, Sets, and Dictionaries Regular Expression Operations, Modules. Object oriented programming in python: Classes, Constructors, Object Methods.	

MODULE 2	**10Hrs**
NumPy - Overview, NumPy Array creation and basic operations, NumPy Universal functions, Selecting and retrieving Data, Data Slicing. Pandas - Overview, Object Creation: Series Object, Data Frame Object, View Data, selecting data by Label and Position, Data Slicing, Setting Data, applying functions to data, Analyzing Data for missing values. Matplotlib - Overview, creating basic chart: Line Chart, Bar Charts and Pie Charts, Plotting from Pandas object, Saving a plot.	
MODULE 3	**08Hrs**
Neural Network basics: History behind neural networks, Relationship between biological neuron and artificial neuron, Perceptron and working mechanism, Architecture of artificial neural network, Types of activation functions, Demo using keras framework, Back propagation and gradient descent, Tensor flow 2.0.	
MODULE 4	**08Hrs**
Introduction to Supervised learning, Linear Regression Logistic Regression, Naive Bayes, Decision Tree, KNN, Random forest, Support Vector Machine Introduction to Unsupervised learning, PCA, clustering approaches: K-means, Hierarchical clustering Natural Language Processing: Natural Language Processing: Language models, n-grams, Vector space models, Bag of words, Text classification. Information retrieval.	
MODULE 5	**08Hrs**
Machine learning application using python for mechanical engineering datasets: mechanical vibrations - heat transfer - fluid mechanics – manufacturing process. Smart Manufacturing, Smart Transportation and Autonomous Vehicles. Robotics, Quality control.	

TEXT BOOKS :

1. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real-world applications powered by the latest AI advances. Packt Publishing Ltd; 2018.
2 Sebastian Raschka and Vahid Mir Jalili, Python Machine Learning, Second Edition: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow Paperback – September 20, 2017

REFERENCES :

1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19OE0015**					
TITLE OF THE COURSE	**AUTOMOBILE ENGINEERING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance &their safety

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain components of automotive vehicle	L1
CO2	Describe functioning of automotive transmission system	L1
CO3	Calculate the resistance offered to the automobile by various factors	L2
CO4	Describe various electrical components used in automobiles	L1
CO5	Diagnosis the faults of automobile vehicles.	L2

COURSE CONTENT:	
MODULE 1	**08Hrs**
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	

MODULE 2	**08Hrs**
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	**10Hrs**
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. **Steering System:** Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. **Suspension**: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers **Brakes:** Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	**08Hrs**
Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	**08Hrs**
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. **Lighting System & Accessories:** Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. **Vehicle maintenance** Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

1. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13thEdition, Elsevier publications
2. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering ", SAE Publications

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**19OE0016**					
TITLE OF THE COURSE	**RAPID MANUFACTURING TECHNOLOGIES**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To provide knowledge of methods for the manufacturing of prototypes from computer based models
- To understand the entire process of direct manufacturing from the creation of computer based models to their physical realization
- To understand the various methods of manufacturing and their merits, demerits and applications
- To impart students to convert CAD models into real life engineering components

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the various rapid prototyping technologies ,	L1
CO2	Select appropriate technology for product development	L2
CO3	Describe rapid prototyping techniques	L1
CO4	Analyse the quality of a product using rapid prototyping technique	L3
CO5	Describe application of rapid prototyping	L1

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction- Need for the compression in product development, Historical development, Fundamentals of RP, Advantages and Classification of RP systems. Process chain, RP Data	

Formats, Information flow in an RP system.	
MODULE 2	**10Hrs**
Stereo lithography Apparatus (SLA): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Solid ground curing (SGC): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications.	
MODULE 3	**10Hrs**
Fused Deposition Modelling (FDM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Laminated Object Manufacturing (LOM):Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Ballistic Particle Manufacturing (BPM): Principle.	
MODULE 4	**10Hrs**
Selective laser sintering (SLS): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Three dimensional Printing (3DP): Principle, process parameters, process details, machine details, products, Advantages, Limitations, applications. Laser Engineering Net Shaping (LENS) - Principle. Concept modellers like thermal jet printers, Sander's model maker, GenisysXs 3D printers, JP system 5, Object Quadra system.	
MODULE 5	**10Hrs**
Introduction to rapid tooling: Direct soft tooling- casting molds, Direct AIM, composite tooling. ndirect soft tooling- spray metal molding, silicon rubber molds, Castable resin and ceramic molds. Direct hard tooling-rapid tool, Laminated metal tooling, DMLS tooling. Indirect hard tooling- 3D keltool, ED electrodes, Ecotool, copy milling. Applications: Application-Material Relationship, Applications in Design, Applications in Engineering, Analysis and Planning. Application of Rapid prototyping in biomedical, automotive, aerospace, jewellery and coin industries.	

TEXT BOOKS :

1. C. K.Chua, K. F.Leong and C. S.Lim, Rapid prototyping: Principles and applications, World Scientific Publishers, 2003

REFERENCES :

1. Andreas Gebhardt, Hanser , Rapid prototyping, Gardener Publications, 2003.
2. L.W.Liou, F.W. Liou, Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press, 2007.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3601**					
TITLE OF THE COURSE	**Design of Machine Elements - II**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**1**	**2**	**-**	**70**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV/II	19ME2402	Mechanics of Materials

COURSE OBJECTIVES :

- To understand use of different types of springs and determine safe design of spring under static and fluctuating loading conditions.
- To understand the standard nomenclature, forces, failures, application, design procedure of Spur and Helical gears (As per AGMA)
- To understand the standard nomenclature, forces, failures, application, design procedure of Bevel and Worm gears (As per AGMA) and to determine standard geometry under given loading condition
- To understand the design procedure, failures and application of Ball Bearings and Sliding contact bearing
- Design clutches and brakes required for power transmission.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Classify different kinds of springs, gears, bearings, clutches and brakes.	L2
CO2	Compute tooth strength for spur, helical, bevel and worm gears	L3
CO3	Interpret the pressure distribution in a journal bearing.	L3
CO4	Analyze the design of hydrodynamic journal bearing.	L4
CO5	Select suitable clutch plate and break shoe for a given applications.	L2

COURSE CONTENT:	
MODULE 1	**08Hrs**
Springs: Types, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads. Leaf	

springs: Stresses in leaf springs. Equalized stresses, energy stored in springs, torsion, Belleville and rubber springs.	
MODULE 2	**10Hrs**
Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads.	
MODULE 3	**08Hrs**
Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Worm Gears: Definitions, design based on strength, dynamic, wear loads and efficiency of worm gear drives.	
MODULE 4	**08Hrs**
Bearings: Lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, Heat dissipated, bearing materials, examples of journal bearing and thrust bearing design.	
MODULE 5	**08Hrs**
Clutches & Brakes: Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Determination of pressure distribution in journal bearing
2.	Modelling and stress analysis of Spur and Helical Gear tooth by using CAD/CAE software
3.	Modelling and stress analysis of helical and leaf springs using CAD/CAE software
4.	Modelling and stress analysis of brake by using CAD/CAE software
5.	Modelling and stress analysis of single plate and multi-plate clutches by using CAD/CAE software
6.	Open ended project using FEA software

TEXT BOOKS :

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

REFERENCES :

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

3. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
4. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3602**					
TITLE OF THE COURSE	**Finite Element Methods**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**1**	**2**	**-**	**70**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1.			

COURSE OBJECTIVES :

- To help students to differentiate between finite difference and finite volume methods
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range two-dimensional real world structural and thermal problems
- To help students understand the use of higher order finite elements

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Differentiate between finite difference and finite volume methods and their applications.	L3
CO2	Analyze a wide range two-dimensional field problems using finite element techniques	L2
CO3	Apply FE techniques to situations involving heat transfer by conduction	L3
CO4	Apply FE techniques in structural and solid mechanics	L3
CO5	Appreciate the use of higher order elements in FEM and apply the same	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.	

MODULE 2	**08Hrs**
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,	
MODULE 3	**08Hrs**
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin – 2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,	
MODULE 4	**08Hrs**
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,	
MODULE 5	**08Hrs**
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two-dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28	
1.	Bars of constant cross section area, tapered cross section area and stepped bar
2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)
3.	Dynamic analysis 1) Fixed – fixed beam for natural frequency determination 2) Bar subjected to forcing function 3) Fixed – fixed beam subjected to forcing function

	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)
4.	Stress analysis of a rectangular plate with a circular hole

TEXT BOOKS :

1. "Applied Finite Element Analysis", L.J.Segerlind, John Wiley and Sons
2. "Applied Finite Element Analysis", G.Ramamurthy, I.K.International Publishing House ,2009

REFERENCES :

1. "Concepts and Applications of Finite Element Analysis", Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R. J. Wiley Student Edition, Fourth Edition, First Reprint 2007.

2. "The Finite Element Method in Engineering", Rao, S. S., Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd., 2007.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3603**					
TITLE OF THE COURSE	**Mechanical Vibrations (Theory & Practice)**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**2**	**-**	**70**	**4**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

- To learn analytical, experimental, and numerical analysis of vibrational phenomena.
- To learn the mathematical modelling of mechanical systems
- To understand the application of the law of conservation of energy in solving problems through energy methods.
- To understand the importance of damping in mechanical systems
- To design the vibration absorbers and isolators
- To acquaint with the principles of vibration measuring instruments

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Construct mathematical models to represent dynamic systems	L3
CO2	Analyse vibratory responses of single, two and multi degree of freedom mechanical systems	L4
CO3	Demonstrate the knowledge of vibration measuring instruments	L3
CO4	Apply AI techniques to Vibration Analysis of mechanical systems	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction, classification of vibration systems, harmonic motion, natural frequency & response, effects of vibration, superposition of simple harmonic motions, Single degree freedom system- equation of motion, Free vibration, equivalent systems, torsional vibrations, vibrations of systems with viscous damping, Logarithmic decrement, energy dissipation in viscous damping.	
MODULE 2	**08Hrs**
Forced vibration, harmonic excitation with viscous damping, steady state vibrations, forced vibrations with rotating and reciprocating unbalance, support excitation,	

vibration isolation, transmissibility, displacement, velocity and acceleration measuring instruments.	
MODULE 3	**08Hrs**
Introduction, principal modes, torsional system with damping, coupled system, principle of vibration absorber, undamped dynamic vibration absorbers, torsional vibration absorber, centrifugal pendulum absorbers, vibration isolators and dampers.	
MODULE 4	**08Hrs**
Numerical Analysis- Influence coefficients, reciprocal theorem, torsional vibration of multi-degree rotor system, Rayleigh's method, Dunkerely's, Holzer's and Stodola methods, Rayleigh-Ritz method, critical speed of shafts, whirling of uniform shaft, shaft with one disc with and without damping, multi-disc shafts, secondary critical speed.	
MODULE 5	**08Hrs**
Vibration instruments – transducer, vibrometer, accelerometer, seismometer, vibration pickup, proximity probe spectrum analyzer, principle of seismic instruments, frequency measuring instruments, diagnostic tools, Introduction to condition monitoring and fault diagnosis using Artificial Intelligence approach.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Plotting and analysis of various graphs of free and forced vibrations using MATLAB.
2.	Virtual lab exercises provided by MHRD
3.	Free and forced vibration
4.	Whirling of the shaft and finding the critical speed of the shaft.
5.	Students will be trained in MATLAB and ANSYS for solving simple vibration problems and using AI & ML techniques in condition monitoring.

TEXT BOOKS :

1. Rao.S.S, Mechanical Vibrations, 6thEdition, Pearson Education Inc. Delhi 2018.
2. Thomson.W.T, Theory of Vibration and its Applications, 5thEdition, Prentice Hall, New Delhi, 2001.

REFERENCES :

1. Rao.J.S and Gupta.K, Introductory Course on Theory and Practice of Mechanical Vibrations, New Age International, New Delhi, 1999.
2. Ramamurthi.V, Mechanical Vibration Practice with Basic Theory, 1st Edition, Narosa Publishing House, Chennai, 2000.
3. Keith Mobley.R, Vibration Fundamentals, Plant Engineering Maintenance Series, Elsevier, 2007.
4. 4. S.Graham Kelly, Mechanical Vibrations - Schaum's outline series, McGraw Hill, 2007

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3604**					
TITLE OF THE COURSE	**PRODUCT DESIGN AND MANUFACTURING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing
- To introduce students to the basic principles and evaluation methods of various aspects of designing components
- To teach students about the Industrial manufacturability requirements
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
CO2	Construct product planning and specification documents	L3
CO3	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
CO4	Apply design for excellence (DF-X) concepts in product design	L3
CO5	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	**08Hrs**
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies.	

MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies.	
MODULE 3	**08Hrs**
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies.	
MODULE 4	**08Hrs**
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies.	
MODULE 5	**10Hr**
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	

TEXT BOOKS :

1. A C Chitale and R C Gupta, Product Design and Manufacturing **-**, PH1, - 3rd Edition, 2003

REFERENCES :

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000
2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997 3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3605**					
TITLE OF THE COURSE	**SURFACE ENGINEERING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES :

- To understand the importance of surface modification, fundamental mechanisms of wear and various types of corrosion
- To understand the difference between surface modification and deposition
- To study the vapour deposition techniques
- To understand the thermal spray methods
- To increase the tribological life of materials

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Demonstrate knowledge on Friction, Wear and Corrosion	L3
CO2	Illustrate surface modification processes	L3
CO3	Explain various Surface deposition processes	L2
CO4	Demonstrate the knowledge of thin coatings	L3
CO5	Describe advanced spraying techniques for industrial applications	L2

COURSE CONTENT:	
MODULE 1	**08Hrs**
Introduction - tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, roles of friction and lubrication- overview of different forms of corrosion.	
MODULE 2	**08Hrs**
Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices.	

MODULE 3	**08Hrs**
Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electro composite plating, properties of electro deposits, electroless composite plating; application areas, properties.	
MODULE 4	**08Hrs**
Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD.	
MODULE 5	**10Hrs**
Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, detonation gun and high velocity oxy-fuel processes, laser surface alloying, laser cladding, specific industrial applications, tests for assessment of wear and corrosion.	

TEXT BOOKS :

1. Sudarshan T S, Surface modification technologies - An Engineers Guide, Marcel Dekker, Newyork, First edition, 1989.

REFERENCES :

1. D.S.Rickerby and A.Matthews, Advanced Surface Coatings: a Handbook of Surface Engineering, Springer Netherlands, First edition, 1991.
2. Varghese C.D, Electroplating and other Surface Treatments - A Practical Guide", Tata McGraw-Hill, First edition, 1993.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3606**					
TITLE OF THE COURSE	**RENEWABLE ENERGY SOURCES**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	III/II	19ME2304	THERMODYNAMICS

COURSE OBJECTIVES :

- Describe the environmental aspects of non-conventional energy resources. In Comparison with various conventional energy systems, their prospects and limitations.
- 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.
- Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.
- Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications
- Compare Solar, Wind and bio energy systems, their prospects, Advantages and limitations.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the environmental aspects of non-conventional energy resources	L2
CO2	Evaluate the use of solar energy for applications including heating, cooling, desalination, power generation, drying and cooking	L2
CO3	Discuss need of Wind Energy and the various components used in energy generation	L2
CO4	Apply concepts of Biomass energy resources and their classification, types of biogas Plants- applications	L2
CO5	Explain Tidal, OTEC, Hydel, Geothermal and Hydrogen Energy concepts as an alternate energy source	L4

COURSE CONTENT:	
MODULE 1	**08Hrs**
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors- flat plate collectors, concentrating collectors – applications Principle of photovoltaic conversion of solar energy -Types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting. Solar PV System Design	
MODULE 2	**08Hrs**
Wind Energy- Wind energy - energy chains - application - historical background, meritsand limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS). Wind power design calculations.	
MODULE 3	**08Hrs**
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis- biogas generation - factors affecting bio- digestion - classification of biogas plant.	
MODULE 4	**10Hrs**
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes –requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles – micro & mini hydel energy: - geothermal energy: geothermal energy sources - power plant and environmental issues. Energy analysis of geothermal plant.	
MODULE 5	**08Hrs**
Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production - direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production - storage of hydrogen - gaseous, cryogenic and metal hydride - fuel cell – principle of working, construction and applications.	

TEXT BOOKS :

1. Tiwari and Ghosal (2007), Renewable energy resources: Narosa publication.

REFERENCES :

1. Twidell& Weir (2015), Renewable Energy Sources: CRC Press.
2. S.P. Sukhatme (2008), Solar Energy/ Tata McGraw-Hill.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3607**					
TITLE OF THE COURSE	**ROBOTICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	V/III	19ME3502	KINEMATICS AND THEORY OF MACHINES

COURSE OBJECTIVES :

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
CO2	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
CO3	To choose the appropriate Sensor and Machine vision system for a given application	L3
CO4	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
CO5	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	**08Hrs**
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	**08Hrs**
Drive system, control system, robot drive mechanisms, hydraulic – electric – servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	**08Hrs**
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	**08Hrs**
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS :

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES :

1. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
2. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3608**					
TITLE OF THE COURSE	**COMPUTER AIDED DESIGN**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES :

- Provide basic foundation of computer aided design for mechanical engineering design processes
- To impart the principles of computer graphics with mathematical simulation
- To understand the fundamentals used to create and manipulate geometric models
- Discuss different solid and surface modelling techniques and its transformation.
- To understand the various data exchange formats in CAD

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Describe basic structure of CAD workstation, Memory types, input/output devices, display devices and computer graphics.	L2
CO2	Construct the different wireframe and surface primitives using parametric representations	L3
CO3	Demonstrate the different solid primitives using different representation schemes	L3
CO4	Apply geometric transformations on the created wireframe, surface and solid models.	L3
CO5	Interpret the different formats and translation of CAD data exchange	L2

COURSE CONTENT:	
MODULE 1	**10Hrs**
Product cycle- Design process- sequential, concurrent engineering and its implementation assessment related case studies. Computer aided design – CAD system architecture- Computer graphics – co-ordinate systems- 2D and 3D transformations homogeneous coordinates - Line drawing -Clipping- viewing transformation.	

MODULE 2	**08Hrs**
Parametric representation of lines: Locating a point on a line, parallel lines, perpendicular lines, distance of a point, Intersection of lines. Parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation. Bezier Curve: equations, properties. Properties and advantages of B-Splines and NURBS. Various types of surfaces along with their typical applications.	
MODULE 3	**08Hrs**
Geometry and Topology, Comparison of wireframe, surface and solid models, Properties of solid model, properties of representation schemes, Concept of Half-spaces, Boolean operations. Schemes: B-rep, CSG, Sweep representation, ASM, Primitive instancing, Cell Decomposition and Octree encoding.	
MODULE 4	**08Hrs**
Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.	
MODULE 5	**08Hrs**
Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images- Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc. - communication standards-LAN, WAN. Case studies related to CAD data exchange.	

TEXT BOOKS :

1. "CAD/CAM - Theory and Practice", Zeid Ibrahim, McGraw Hill education, 2nd edition, 2009.
2 "Mathematical Elements for Computer Graphics", Rogers, D. F. and Adams, J. A., McGraw Hill education, 2nd edition, 2017.

REFERENCES :

1. "CAD/CAM: Principles and Applications", Rao, P.N., McGraw Hill Publication, 2nd Edition, 2004.
2. "Computer Aided Graphical Design", Rayan, D. L., Marcel Dekker Inc., Subsequent edition, 1985.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3609**					
TITLE OF THE COURSE	**PRINCIPLES OF FRACTURE MECHANICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV	19ME2402	MECHANICS OF MATERIALS

COURSE OBJECTIVES :

- The course will give much knowledge on fracture mechanics principles, fatigue failure and non-destructive testing and their applications.
- Test methods and other techniques for fracture study will be discussed.
- The syllabus is designed for students interested in basic building knowledge on mechanics and learns more on engineering materials against crack induced fracture, diagnosis of cause and mechanisms of failure.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the basic concepts of fracture mechanics	L2
CO2	Describe the concept of stress and displacement fields in isotropic elastic materials	L2
CO3	Apply the mixed mode fracture criteria for predicting the crack growth	L3
CO4	Able to possess the analytical tools needed to solve the idealised problem	L3
CO5	Apply the NDT method for crack detection	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
Kinds of failure, historical aspects, brittle and ductile fracture, modes of fracture failure, damage tolerance, griffith's dilemma, surface energy, griffith's analysis, energy release rate, energy release rate of DCB specimen, crack resistance, stable and unstable crack growth, r-curve for brittle cracks, thin plate vs thick plate, critical energy release rate	

MODULE 2	08Hrs
Investigations Closer to the Crack Tip, Linear Elastic Fracture Mechanics (LEFM), Stress and Displacement Fields in Isotropic Elastic Materials, Background for Mathematical Analysis, Westergaard's Approach, Edge Cracks, Embedded Cracks, The Relation between G1 and K1, Critical Stress Intensity Factor, Further Investigation at the Crack Tip, Approximate Shape and size of the plastic zone, Effective crack length, Effect of plate thickness, Crack tip opening displacement, problems.	
MODULE 3	**08Hrs**
Fracture Surface, Mixed Mode Crack Propagation Criteria: Modified Griffith Criterion, Maximum Tangential Stress Criterion, Strain Energy Density Criterion, An Example of Mixed-Mode, crack growth	
MODULE 4	**08Hrs**
KIc-Test Technique, Various Test Specimens, Constraints on Specimen-Dimensions, Fatigue Crack Growth to Sharpen the Tip, Clip Gauge, Load-Displacement Test, Measuring the Crack Length, Data Analysis, Comments on Plane Strain K1c-Test	
MODULE 5	**08Hrs**
Examination through Human Senses, Liquid Penetration Inspection, Ultrasonic Testing, Radiographic Imaging, Magnetic Particle Inspection,	

TEXT BOOKS :

1. Ralph I. Stephens, Ali Fatemi, Robert R. Stephens, Henry O. Fuchs, Metal Fatigue in engineering, John Wiley New York, Second edition. 2001.
2. Jack. A. Collins, Failure of Materials in Mechanical Design, John Wiley, New York 1992.

REFERENCES :

1. David Broek, Elementary Engineering Fracture Mechanics, ArtinusNijhoff, London 1999.
2. Suresh, S., Fatigue of Materials, Cambridge University press, Cambridge, U.K.1991.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3610**					
TITLE OF THE COURSE	**Internal Combustion Engines**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV	19ME2401	APPLIED THERMODYNAMICS

COURSE OBJECTIVES :

- To understand working, and construction of internal combustion engines.
- To understand testing and performance of SI and CI engines.
- To study the combustion phenomenon in SI and CI engines.
- To study sources of emissions from internal combustion engines
- To understand various emission control techniques and emission norms.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse thermodynamic cycles used for IC engine applications	L4
CO2	Explain operating characteristics of different engine and combustion process for SI and CI engines.	L2
CO3	Compare various types of Combustion chambers for IC engine application	L4
CO4	Discuss the various systems used in IC Engine	L2
CO5	Describe the emission norms including Bharat Stage & international norms and Emission control Methods	L2

COURSE CONTENT:	
MODULE 1	**08Hrs**
Heat engine, internal combustion engines and external combustion engines, internal combustion engine construction - components and materials, engine nomenclature, valve timing diagram, intake and exhaust system, engine classification, applications. Fuel air cycle and actual cycle: fuel air cycle, assumptions, comparison with air standard cycle, effect of variables on performance, actual cycle and various losses.	
MODULE 2	**10Hrs**
Theory of carburetion, types of carburetors, electronic fuel injection system, combustion in spark ignition engines, stages of combustion, flame propagation, rate of	

pressure rise, abnormal combustion, phenomenon of detonation in spark ignition engines, effect of engine variables on detonation. Combustion chambers, rating of fuels in spark ignition engines.	
MODULE 3	**08Hrs**
Fuel supply system, types of fuel pump, injector and distribution system, combustion in compression ignition engines, stages of combustion, factors affecting combustion, phenomenon of knocking in compression ignition engine. Effect of knocking, methods of knock control, types of combustion chambers, rating of fuels in compression ignition engines. Dopes &additives, comparison of knocking in spark ignition & compression ignition engines.	
MODULE 4	**08Hrs**
Requirements of combustion chambers, features of different types of combustion chambers system for S.I. engine. I-head, F-head combustion chambers. C.I. engine combustion chambers-air swirl turbulence, M-type combustion chamber. Comparison of various types of combustion chambers.	
MODULE 5	**08Hrs**
Internal combustion, Engine Systems: Cooling system, lubrication system, ignition system, governing system, starting system. Internal combustion engine emissions and control air pollution due to internal combustion engine and its effect, emissions from petrol/gas and diesel engines, sources of emissions, euro norms, Bharat stage norms, emission control methods for spark ignition and compression ignition engines.	

TEXT BOOKS :

1. V. Ganesan(2012, Internal Combustion Engines, Tata McGraw-Hill,

REFERENCES :

1. Heywood(2011), Internal Combustion Engine Fundamentals, Tata McGraw-Hill
2. Colin R. Ferguson C(1986),Internal Combustion Engines, John Wiley & sons

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3611**					
TITLE OF THE COURSE	**MODELLING AND SIMULATION OF MANUFACTURING SYSTEMS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	V	19ME3504	Manufacturing Technology

COURSE OBJECTIVES :

- To introduce the concepts of simulation and to apply them for manufacturing system
- To develop simulation model for dynamic discrete event stochastic system.
- To learn the way of analyzing the systems.
- To classify the systems based on the nature of dynamics and knowledge of elements.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain various simulation models	L1
CO2	Interpret the Dynamic Discrete event stochastic system.	L2
CO3	Compare simulation model for the said system	L4
CO4	Correlate the model and present the results to specified confidence level.	L4
CO5	Develop the Simulations for flow & job shop system	L6

COURSE CONTENT:	
MODULE 1	**08Hrs**
System - ways to analyze the system - Model - types of models - Simulation - Definition - Types of simulation models - steps involved in simulation - Advantages & Disadvantages. Parameter estimation-estimator - properties - estimate - point estimate – confidence interval estimates-independent-dependent-hypothesis - types of hypothesis- step - types l& 2 errors - Framing - string law of large numbers.	
MODULE 2	**10Hrs**
Building of Simulation model validation - verification - credibility - their timing - principles of valid simulation Modeling - Techniques for verification - statistical	

procedures for developing credible model. Modeling of stochastic input elements - importance - various procedures - theoretical distribution - continuous - discrete their suitability in modeling.	
MODULE 3	**08Hrs**
Generation of random variables - factors for selection methods - inverse transform – composition convolution - acceptance - rejection - generation of random variables - exponential-uniform-weibull-normal Bernoullie - Binomial uniform - poisson - Simulation languages - comparison of simulation languages with general purpose languages Simulation languages vs Simulators - software features - statistical capabilities - G P S S - S1MAN- SIMSCRIPT - Simulation of WMJI queue - comparison of simulation languages.	
MODULE 4	**08Hrs**
Output data analysis - Types of Simulation w. r. t output data analysis - warm up period- Welch algorithm - Approaches for Steady- State Analysis- replication- Batch means methods- corn pan Sons.	
MODULE 5	**08Hrs**
Applications of Simulation - flow shop system- job shop system - M/MI1 queues with infinite and finite capacities - Simple fixed period inventory system - New boy paper problem.	

TEXT BOOKS :

1. Curry, G. L., & Feldman, R. M. (2010). Manufacturing systems modeling and analysis. Springer Science & Business Media.

REFERENCES :

1. Syng Yup Ohn and Sung Do Chi (2015) , “Model Design and Simulation Analysis”,Springer,.
2. F Carl Knopf (2011), Modeling, Analysis and Optimization of Process and Energy Systems, Wiley Publication.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3612**					
TITLE OF THE COURSE	**Advanced Material Technology**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III	19ME2302	ENGINEERINGMATERIALS

COURSE OBJECTIVES :

- To impart knowledge to students in the latest technological topics on material technology.
- To provide them with opportunities in taking up advanced topics in the field of research.
- To equip students with recent study and advancement on novel materials.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Summarize the properties of existing and advanced materials	L2
CO2	Classify the existing metallic & non-metallic materials for manufacturing applications	L2
CO3	Discuss the behaviour of materials under various service conditions mechanisms of failure of materials	L2
CO4	Demonstrate micro and nanofabrication techniques and processing of materials	L3
CO5	Analyze the fracture behaviour of materials	L4

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction to advanced materials, Super alloys, Ferro electric and piezoelectric materials, Advanced magnetic materials, Smart 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.	

MODULE 2	08Hrs
Modern Metallic materials: Dual phase steels, Micro alloyed, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) steel, Maraging steel - Intermetallics, Ni and Ti aluminides - Smart materials, shape memory alloys – Metallic glass - Quasi crystal and nano crystalline materials, bio materials. Non-Metallic Materials: Plastics, rubber, foams, adhesives and coatings - Structure, properties and applications of engineering polymers - Advanced structural ceramics, processing and applications.	
MODULE 3	**08Hrs**
Behaviour: Tensile testing, other tests of plastic behaviour, strain hardening of metals, strain rate and temperature dependence, slip, Hardening mechanisms in metals, dynamic strain aging; ductility and fracture, fracture mechanics theories, Creep mechanisms, Mechanical behavior of ceramics and glasses. Performance: Corrosion and its control, Performance of materials at High & low temperatures, Radiation damage and recovery.	
MODULE 4	**08Hrs**
Introduction to Micro and Nano manufacturing technology, advantages and applications of nanotechnology, Overview of Nano Fabrication Methods: Top-down and bottom-up approaches, lithography, deposition, Chemical Vapour Deposition, Physical Vapour Deposition, etching, and material modification methods, processes and equipment.	
MODULE 5	**08Hrs**
Griffith's theory, stress intensity factor and fracture toughness - Toughening mechanisms - Ductile, brittle transition in steel - High temperature fracture, creep - Larson-Miller parameter - Deformation and fracture mechanism maps - Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law - Fracture of nonmetallic materials – Failure Analysis, sources of failure, procedure of failure analysis	

TEXT BOOKS :

1. Thomas H. Courtney, Mechanical Behavior of Materials , McGraw-Hill, 2000.

REFERENCES :

1. Willam D. Callister, Jr., Material Science and Engineering: An introduction, John Wiley & Sons, Inc, 2003.
2. Willam F. Smith, Principles of Materials Science and Engineering, 3rd edition, McGraw Hill, 2002.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19ME3613**					
TITLE OF THE COURSE	**DEEP LEARNING & IMAGE PROCESSING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES :

- Introduction to the deep learning.
- Basics of deep learning and its history, State-of-the-art deep neural net models in computer vision; Specific tools and packages to train these deep nets.
- Understand Deep feed forward networks, regularization for deep networks.
- Understand about convolutional neural networks, recurrent neural networks, practical methodology and applications.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains	L2
CO2	Compare and explain various deep learning architectures and algorithms.	L2
CO3	Demonstrate the applications of deep learning in various fields.	L3
CO4	Implement deep learning algorithms and solve real-world problems.	L3
CO5	Execute performance metrics of Deep Learning Techniques.	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
Learning Algorithms, Capacity, Overfitting and Underfitting, Hyperparameters and Validation Sets, Estimator, Bias and Variance, Maximum Likelihood Estimation, BayesianStatistics, Supervised Learning Algorithms, Unsupervised Learning Algorithms, Stochastic Gradient Decent, building a Machine Learning Algorithm, Challenges Motivating Deep Learning.	

MODULE 2	**08Hrs**
Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation. **Regularization:** Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Regularization and Under-Constrained Problems, Dataset Augmentation, Noise Robustness, Semi-Supervised Learning, Multi-Task Learning, Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging, Dropout.	
MODULE 3	**08Hrs**
How Learning Differs from Pure Optimization, Challenges in Neural Network Optimization, Basic Algorithms. Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates.	
MODULE 4	**08Hrs**
The Convolution Operation, Motivation,Pooling, Convolution and Pooling as an Infinitely Strong Prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features.	
MODULE 5	**08Hrs**
Recurrent and Recursive Nets: Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks, And Recursive Neural Networks. Long short-term memory.	

TEXT BOOKS :

1. Goodfellow L., Bengio Y. and Courville A., Deep Learning, MIT Press (2016).

REFERENCES :

1. Haykin S., Neural Network and Machine Learning, Prentice Hall Pearson (2009), 3rd ed.
2. Geron A., Hands-on Machine Learning with Sci-kit and TensorFlow, O'Reilly Media (2017)

OPEN ELECTIVE – II

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19OE0017**					
TITLE OF THE COURSE	**ROBOTICS ENGINEERING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
CO2	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
CO3	To choose the appropriate Sensor and Machine vision system for a given application	L3
CO4	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
CO5	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	**08Hrs**
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	**08Hrs**
Drive system, control system, robot drive mechanisms, hydraulic – electric – servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	**08Hrs**
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	**08Hrs**
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS :

1. AshitavaGhosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES :

1. Fu, K. S, Gonzalez, R. C, Lee, C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987

2. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**19OE0018**					
TITLE OF THE COURSE	**PRODUCT DESIGN AND MANUFACTURING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing.
- To introduce students to the basic principles and evaluation methods of various aspects of designing components.
- To teach students about the Industrial manufacturability requirements.
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
CO2	Construct product planning and specification documents	L3
CO3	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
CO4	Apply design for excellence (DF-X) concepts in product design	L3
CO5	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	**10Hrs**
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies	

MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies	
MODULE 3	**08Hrs**
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies	
MODULE 4	**08Hrs**
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies	
MODULE 5	**08Hrs**
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	

TEXT BOOKS :

1. A C Chitale and R C Gupta, Product Design and Manufacturing **-**, PH1, - 3rdEdition, 2003

REFERENCES :

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development **-** McGraw Hill -2000.
2. Tim Jones, Butterworth Heinmann, New Product Development Oxford. UCI -1997 3. GeofferyBoothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002

VII SEM - MECHANICAL ENGINEERING SYLLABUS

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4701**					
TITLE OF THE COURSE	**CONTROL SYSTEMS ENGINEERING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**2**	**-**	**70**	**4**

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1.			
2.			

COURSE OBJECTIVES :

- Mathematical Modeling, of mechanical and electromechanical control systems
- Characteristics and performance of feedback systems: transient and steady state response of lower order systems
- Stability analysis of feedback systems using Routh- Hurwitz criterion, root locus method, stability in frequency domain using polar plots, bode plots, performance specifications
- Basic concepts of digital control systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate an understanding of the fundamentals of (feedback) control systems	L2
CO2	Express and solve system equations in state-variable form (state variable models)	L3
CO3	Apply root-locus technique to analyze and design control systems	L3
CO4	Use of Matlab to simulate the control systems	L3

COURSE CONTENT:	
MODULE 1 : Introduction to Automatic Control Systems	**10Hrs**
Concept of automatic controls, Examples of control systems, open and closed loop systems, concept of feedback, requirements of an ideal control system. Mathematical Modeling Introduction, Review of Laplace transforms, Transfer functions, Transfer function Models, Mechanical systems (both translation and rotational), Problems on	

Transfer functions. Electrical Analog of mechanical systems: Force-voltage, Force-current analogies, Models of thermal and hydraulic systems. Block diagrams and signal flow graphs: Block representation of system elements, reduction of block diagrams. Signal flow graphs: Mason's gain formula
MODULE 2 : System Response **08Hrs**
Introduction, Transient & Steady state response analysis ,Standard test inputs, First order and second order system response to unit step, ramp inputs, concept of time constant and its importance in speed of response. Steady State Error, Static and Dynamic Error Constants. System stability, Routh-Hurwitz Criterion.
MODULE 3 : Stability, R-H criterion, Root Locus **08Hrs**
The root locus concept, Guidelines for sketching root loci, Selected illustrative root loci.
MODULE 4 : Frequency response –Polar, Nyquist, Bode Diagrams **08Hrs**
Frequency response –Polar, Nyquist, Bode Diagrams:Polar plots, Nyquist Stability Criterion, Stability analysis, Relative stability concepts, Phase and gain margin, M&N circles. Frequency response analysis using Bode plots:Bode attenuation diagrams, Stability Analysis using Bode plots, Simplified Bode Diagrams.
MODULE 5 : Introduction to P-I-D controllers **08Hrs**
Proportional Integral, Proportional Integral Differential controllers. Analysis of control systems in state space: Introduction to state concepts, state-space representation of transfer-function systems, controllability and observability. Introduction to Digital control systems: Introduction, Advantages offered by digital controls.

List of Laboratory/Practical Experiments activities to be conducted (if any)	**28Hrs**
• Simulation of a typical first order & second order system and determination of step response of the system using MatLab	
• Determine the frequency response of second order system and evaluation of frequency domain specifications using MatLab	
• Obtain the root locus plot for the given open loop transfer function G(s) H(s)	
• Using MatLab SIMULINK, simulate the linear systems to compare their step responses.	
• Using MatLab SIMULINK, simulate the feedback systems	

TEXT BOOKS :

1. Katsuhiko Ogata, Modern Control Engineering, Second edition, Prentice Hall of India Private Ltd, NewDelhi, 1995.
2. Nagrath I J and Gopal .M, Control Systems Engineering, FirstEdition,Wiley and sons, 1985

REFERENCES :

1. Benjamin C Kuo, Automatic Control System, 7thEdition, Prentice Hall of India, Private Ltd, New Delhi, 1993.
2. Richard .C. Dorf and Robert.H.Bishop, Modern Control System Engineering, Addison Wesley, 1999.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4702**					
TITLE OF THE COURSE	**MAJOR PROJECT PHASE – I**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	**-**	**-**	**4**	**70**	**2**

COURSE OBJECTIVES :

- To develop the work practice in students to apply theoretical and practical tools/techniques
- To improve the professional competency
- To improve research aptitude by touching the areas which otherwise not covered by theory or laboratory classes
- To solve real life problems related to industry and current research.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solving of real time problems not necessarily new line of enquiry, but shows that student has interest in research and synthesising skills in producing a contribution to knowledge.	L2
CO2	Builds competency and research aptitude.	L3

The project work for B.Tech consists of Project Work Stage - I and Project Work Stage - II. Project Work Stage - I is to be undertaken during B.Tech VII semester and Project Work Stage - II, which is generally a continuation of Project Work Stage - I and is to be undertaken during B.Tech VIII semester.
GENERAL SUGGESTIONS AND EXPECTATIONS
The Project Work is by far the most important single piece of work in the programme. It provides the opportunity for student to demonstrate independence and originality, to plan and organize a large Project over a long period and to put into practice some of the

techniques student have been taught throughout the course. The students are advised to choose a Project that involves a combination of sound background research, a solid implementation, or piece of theoretical work, and a thorough evaluation of the Project's output in both absolute and relative terms. Interdisciplinary Project proposals and innovative Projects are encouraged and more appreciable.

It is good to try to think of the Project as a deliverable at reviews rather than an effort to deliver a fully functioning 'product'. The very best Projects invariable covers some new ground, e.g. by developing a complex application which does not already exit, or by enhancing some existing application or method to improve its functionality, performance etc.

A straightforward implementation Project is acceptable, but student must appreciate that it is unlikely to gain high marks, regardless of how well it is done and its usage. Likewise,

Projects which are predominantly survey reports, unless they are backed up with experimentation, implementation, on theoretical analysis, e.g. for performing an objective comparison of surveyed methods, techniques etc. pure survey reports with no supporting implementation or theory, are not acceptable.

1. Undergraduate students are to decide on the Project Work Stage - I and Project Work Stage - II Project with their proposal and Project Supervisor during the month of July/August with a Synopsis consisting of about three chapters –
   a. Introduction,
   b. Literature Review
   c. Methodology which should highlight the deliverables.
2. In Case of re-reviews, any number of re-reviews can happen depending on the discretion of the committee and it should happen within the prescribed time.
3. If the student fails to attend, the Supervisor refuses to endorse the student's work.
   The committee can invite Head of the Department who is empowered to resolve among further matters.
4. If the work of the candidate is found to be insufficient and plagiarism, the committee and Head of the Department will decide the further process.
5. Head of the Department can initiate further steps to ensure the smooth implementation as deems appropriate of guidelines.
6. The idea for student's Project may be a proposal from a faculty member or student's own, or perhaps a combination of the two.
7. All B. Tech projects are to be done in the Institute. For industry specified projects, students will be permitted to spend 1-2 weeks in the industry on recommendation by the supervisor. The number of students per batch should be 4.
8. The End Semester evaluation shall be based on the report submitted and a vivavoce exam by committee comprising of the head of the department, project supervisor and an external examiner.

The Departmental Committee (DC) consists of HOD, Supervisor and two senior experts in the department. The committee monitors the progress of Project Work. The DC is constituted by the Principal on the recommendations of the department Head

Student shall register for the Project work with the approval of Departmental Committee in the B.Tech VII semester and continue the work in the B.Tech VIII semester too. The

Departmental Committee (DC) shall monitor the progress of the project work. In

B.TechVII semester, Stage - I of the Project Work is to be completed. A team has to identify the topic of work, collect relevant Literature, preliminary data, implementation tools / methodologies etc., and perform a critical study and analysis of the problem identified.
They shall submit status report in addition to oral presentation before the Departmental Committee for evaluation.
A candidate shall continue the Project Work in B.Tech VIII semester (Stage - II) and submit a Project report at the end of Stage - II after approval of the Departmental Committee. During Stage - II, the teams shall submit status report in addition to oral presentation before the DC. The DC shall evaluate the project for internal marks (Stage - I & II) based on the progress, presentations and quality of work.

PROGRAM ELECTIVE – IV

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4703**					
TITLE OF THE COURSE	**ADVANCED MACHINING PROCESSES**					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:
The objectives of the Course are to

- To make awareness among students on recent trends in advanced machining processes.
- Understand the knowledge of machining over conventional machining.
- Elaborate the fundamentals of advanced machining processes.
- Understand the various processing techniques of advanced machining processes.
- provide a wide knowledge on various advanced machining like Process Parameters , Constructional features , Advantages , Disadvantages and Applications of
- Ultrasonic, Water Jet, Abrasive, EDM, Chemical and Laser Machining.

COURSE OUTCOMES:
After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level

CO1	Understand the compare traditional and non-traditional machining process and recognize the need for Non-traditional machining process.	L2
CO2	Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.	L3
CO3	Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.	L3
CO4	Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.	L4
CO5	Understand the LBM equipment, LBM parameters, and characteristics.	L2

COURSE CONTENT:	
MODULE 1: INTRODUCTION	**09Hrs**
Introduction: Need and classification of nontraditional machining processes – material removal in traditional and nontraditional machining processes - considerations in Process selection. **Ultrasonic Machining:** Introduction, ultrasonic machining system- mechanics of cutting, Parametric analysis- process capabilities, applications. **Water Jet Machining**: Principle, process variables, advantages and disadvantages, Applications, Abrasive water jet machining- pumping system- abrasive feed system abrasive water jet nozzle, catcher, process variables, and applications.	
MODULE 2: ABRASIVE MACHINING	**08Hrs**
Abrasive Jet Machining (AJM): Introduction, abrasive jet machining setup, abrasive feeder, machining chamber, AJM nozzle, parametric analysis - stand-off-distance - abrasive flow rate - nozzle pressure - mixing ratio, applications. **Magnetic Abrasive Finishing (MAF)** - working principle, MAF system, material removal and surface finish, process variables and applications.	
MODULE 3: ELECTRIC DISCHARGE MACHINING:	**08Hrs**
Electric Discharge Machining: Mechanism of material removal, dielectric fluid, electrode materials, spark erosion generators, electrode feed system, material removal rate, advantages and disadvantages, applications. **Wire EDM**: Principle, wire feed system – advantages and disadvantages, applications. Electro-chemical discharge machining: Working principle, process parameters, advantages and disadvantages, applications.	
MODULE 4: CHEMICAL MACHINING:	**09Hrs**

Chemical Machining: Fundamentals, principle, classification, selection of etchant, Chemical milling – engraving – blanking – drilling – trepanning. Advantages and disadvantages – applications. **Electro Chemical Machining:** Electro Chemical Machining process, advantages – disadvantages, applications Electro **chemical grinding**, **honing, deburring, turning.**	
MODULE 5: LASER BEAM MACHINING:	**08Hrs**
Laser Beam Machining: Principle, solid – gas laser methods, applications, thermal features, advantages – disadvantages, applications. Ion Beam Machining: Equipment, process characteristics, advantages, disadvantages. **Plasma Arc Machining** - Metal removal mechanism, process parameters, process characteristics, types of torches, applications.	

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

REFERENCES:

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

SEMESTER	**VII SEM**					
YEAR	**IV**					
COURSE CODE	**19ME4704**					
TITLE OF THE COURSE	GAS DYNAMICS AND JET PROPULSION					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1.			
2.			

COURSE OBJECTIVES :

- To understand the basic difference between incompressible and compressible flow
- To understand the phenomenon of shock waves and its effect on flow. To gain some

basic knowledge about jet propulsion and Rocket Propulsion.

- To illustrate the development of the governing differential, algebraic equations related to different modes of heat transfer.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Will get knowledge to the students on compressible flow through ducts, jet propulsion and space propulsion	
CO2	Understand the basic difference between incompressible and compressible flow.	
CO3	understand the phenomenon of shock waves and its effect on flow	
CO4	understand the jet propulsion	
CO5	learn about the rocket propulsion and rocket engine	

COURSE CONTENT:	
MODULE 1: Basic concepts	
Basic concepts: Energy and momentum equations of compressible fluid flows – Stagnation states – Mach waves and Mach cone – Effect of Mach number on compressibility. Isentropic flows: Isentropic flow through variable area ducts	
MODULE 2: Isentropic Flow	
: Nozzle and Diffusers, compressors and turbines – Use of Gas tables. Flow through ducts: Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – Variation of flow properties – Use of tables and charts – Generalized gas dynamics.	
MODULE 3: Normal and oblique shocks	
Normal and oblique shocks: Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl Meyer relations – Expansion of supersonic flow, Use of table and charts – Applications.	
MODULE 4: Jet propulsion	
Jet propulsion: Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operation principle – cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo-prop engines – Aircraft combustors	
MODULE 5: rocket engines	
Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity -Applications – space flights.	

TEXTBOOKS:

1. Balachandran P. – 'Fundamentals of Compressible Fluid Dynamics' – PHI Learning India Private Ltd. – 2009.
2. Cohen H., Rogers G. E. and Saravanamuttoo – 'Gas Turbine Theory' – Longman – 1980

REFERENCES:

1. Shapiro A. H. – 'Dynamics and Thermodynamics of Compressible Fluid Flow – Vol.I' – John Wiley, New York – 1953
2. Radhakrishnan E. – 'Gas Dynamics' – Prentice-Hall of India Pvt. Ltd – 2004

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4706**					
TITLE OF THE COURSE	**COMPOSITE MATERIALS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The objectives of the Course are to

- Classify composites, introduce common types of fibers and matrices, and manufacturing, mechanical properties and applications of composites
- Review definitions of stress, strain, elastic moduli and strain energy
- Develop stress-strain relationships, elastic moduli, strengths, thermal and moisture expansion coefficients of an angle ply based on those of a unidirectional/bidirectional lamina and the angle of the ply
- IDevelop concepts of volume and weight fraction of fiber and matrix, density and void fraction in composites
- Develop relationships of mechanical and hygrothermal loads applied to a laminate to strains and stresses in each lamina
- Introduce other mechanical design issues in laminated composites
- Recycling of composites

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Identify, describe and evaluate the properties of fibre reinforcements, polymer matrix materials and commercial composites.	L2

CO2	Develop competency in one or more common composite manufacturing techniques, and be able to select the appropriate technique for manufacture of fibre-reinforced composite products.	L3
CO3	Analyse the elastic properties and simulate the mechanical performance of composite laminates; and understand and predict the failure behaviour of fibre-reinforced composites	L3
CO4	Apply knowledge of composite mechanical performance and manufacturing methods to a composites design project	L3
CO5	Critique and synthesise literature and apply the knowledge gained from the course in the design and application of fibre-reinforced composites.	L3

COURSE CONTENT:	
Module 1	**8Hrs**
Introduction to Composite Materials Definition, classification and characteristics of composite materials – fibrous composites, laminated. Matrix materials, Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.	
Module 2	**8Hrs**
Processing of composites Layup and curing, fabricating process - open and closed mould process – hand layup techniques structural laminate bag molding, production procedures for bag molding,Filament winding, pultrusion, pulforming, thermo - forming, injection, injection molding, liquid molding, blow molding.	
Module 3	**10Hrs**
Macro-Mechanical Behavior of a Lamina and laminate: Stress-strain relation for an orthotropic lamina- Restriction on elastic constants Strengths of an orthotropic lamina and Failure theories for an orthotropic lamina.Classical plate theory- Stress and strain variation in a laminate- Resultant forces and moments- A B & D matrix- Strength analysis of a laminate.	
Module 4	**8Hrs**
Micro-Mechanical Behavior of a Lamina Determination of elastic Constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants.	
Module 5	**8Hrs**
Composite and Interfaces Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Composite Strengths, Composite Interfaces, Bonding Mechanisms and Interfacial properties.	

Text books :

1. K.K Chawla,Composites Science and Engineering, SpringerVerlag, 1998
2. R M Jones, “Mechanics of Composite Materials”, McGraw-Hill, NewYork, 1975

Reference:

1. M.M. Schwartz, “Composite materials hand book”, McGraw Hill Book Company. 1984
2. Hull and Clyne, Introduction to Composite materials, Cambridge University Press, 2nd Edition, 1990.
3. Autar Kaw,Mechanics of composites, CRC Press. 2002.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4707**					
TITLE OF THE COURSE	**OPERATIONS RESEARCH**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The objectives of the Course are to

- To appropriately formulate Linear Programming models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these LP problems.
- To interpret and apply the results of an operations research model. Solve specialized linear programming problems like transportation and assignment problems.
- Solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
- Understand the best strategy using decision making methods under uncertainty & uncertainty

COURSE OUTCOMES:

CO No.	Outcomes	Bloom’s Taxonomy Level
CO1	Formulate and solve Linear Programming Problems	L3
CO2	Determine performance measures for basic queuing problems using appropriate closed-form equations	L3
CO3	Develop linear programming (LP) models for shortest path, maximum flow, minimal spanning tree, critical path, minimum cost flow, and transshipment problems.	L3
CO4	Use CPM and PERT techniques, to plan, schedule, and control project activities.	L3
CO5	Propose the best strategy using decision making methods under uncertainty and game theory	L4

COURSE CONTENT:	
MODULE 1	**8Hrs**
Operation Research, Historical Standpoint, Methodology, Different Phases, Characteristics, Scope and Application of Operations Research. Requirement of LP, Basic Assumptions, Formulation of LP, General Statement of LP, Solution techniques of LP: Graphical Methods, Analytical Methods: Simplex, Big M and Two-Phase, Sensitivity Analysis, Primal and Dual Problems, Duality in linear programming problems, dual simplex method.	
MODULE 2	**8Hrs**
Transportation Problems definition, Linear form, Solution methods: Northwest corner method, least cost method, Vogel's approximation method. Degeneracy in transportation, Modified Distribution method, Unbalanced problems and profit maximization problems Transshipment Problems. Assignment problem - Introduction, Mathematical formulation of the problem, Hungarian assignment method only, special cases in assignment problems, Travelling salesman problem.	
MODULE 3	**10Hrs**
Queuing theory - Basic structure of queuing systems, elements of queuing theory, Kendall's Notation, Operating characteristics of a queuing system, roles of the Poisson and exponential distributions, classification of queues basic results of M/M/1: FIFO systems, extension to multi-server queues. Inventory Control - classification, Different costs associated with Inventory, Economic order quantity, Inventory models with deterministic demands.	
MODULE 4	**8Hrs**
Introduction, Characteristics of Game Theory, Two Person, Zero-sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, mx2), Algebraic and graphical methods. CPM & PERT- project scheduling, critical path calculations, Crashing	
MODULE 5	**8Hrs**
Replacement Theory: Replacement of capital equipment which depreciated with time, replacement by alternative equipment, Group and individual replacement policy. Decision Theory: Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwitz criterion, Decision tree.	

TEXTBOOKS:

1. Hamdy. A. Taha, "Operations Research an Introduction", Pearson Education, 17th Edition, 2002.
2. S.D Sharma, "Operation Research", Kedarnath and Ram Nath - Meerut, 2008.

REFERENCES:

1. KantiSwarup, Gupta.P.K. & Man Mohan, Operations Research, S.Chand& Sons, 2005.
2. Joseph.G.Ecker& Michael KupperSchimd, Introduction to Operations Research, John Wiley & Sons, 1988.
3. Gillet. B.E., Introduction to Operations Research - A Computer oriented algorithmic approach, McGraw Hill, 1987.

PROGRAM ELECTIVE – V

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4708**					
TITLE OF THE COURSE	**RAPID MANUFACTURING TECHNOLOGIES**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The objectives of the Course are to

- Provide knowledge of methods for the manufacturing of prototypes from computer-based models
- Confer the entire process of rapid manufacturing from the creation of computer-based models to their physical realization
- Understand the various methods of rapid manufacturing and their merits, demerits and applications
- Impart students to convert CAD models into real life engineering components
- Explore the potential of additive manufacturing in different industrial Applications.

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Discuss the fundamentals of product development and process flow of RP systems	L2
CO2	Distinguish the different liquid-based RP systems and its process limitations	L2
CO3	Interpret the principles of different solid based RP systems and its applications	L3

CO4	Infer the selection of suitable power-based RP systems/concept Modellers based on the application	L3
CO5	Summarize the rapid tooling technology and various applications pertaining to Rapid manufacturing technologies	L2

COURSE CONTENT:	
MODULE 1: INTRODUCTION	**06Hrs**
Introduction- Need for the compression in product development, Historical development, Fundamentals of RP, Advantages and Classification of RP systems. Process chain, RP Data Formats, Information flow in an RP system.	
MODULE 2: LIQUID BASED RAPID PROTOTYPING SYSTEMS	**08Hrs**
Stereo lithography Apparatus (SLA): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Solid ground curing (SGC): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications.	
MODULE 3: SOLID BASED RAPID PROTOTYPING SYSTEMS	**08Hrs**
Fused Deposition Modelling (FDM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Laminated Object Manufacturing (LOM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Ballistic Particle Manufacturing (BPM): Principle.	
MODULE 4: POWDER BASED RAPID PROTOTYPING SYSTEMS AND CONCEPT MODELLERS	**10Hrs**
Selective laser sintering (SLS): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Three-dimensional Printing (3DP): Principle, process parameters, process details, machine details, products, Advantages, Limitations, applications. Laser Engineering Net Shaping (LENS) - Principle. Concept modellers like thermal jet printers, Sander's model maker, Genisys Xs 3D printers, JP system 5, Object Quadra system.	
MODULE 5: RAPID TOOLING AND APPLICATIONS	**10Hrs**
Introduction to rapid tooling: Direct soft tooling- casting molds, Direct AIM, composite tooling. Indirect soft tooling- spray metal molding, silicon rubber molds, Castable resin and ceramic molds. Direct hard tooling-rapid tool, Laminated metal tooling, DMLS tooling. Indirect hard tooling- 3D keltool, ED electrodes, Ecotool, copy milling. Applications: Application-Material Relationship, Applications in Design, Applications in Engineering, Analysis and Planning. Application of Rapid prototyping in biomedical, automotive, aerospace, jewellery and coin industries.	

TEXT BOOKS :

1. C. K.Chua, K. F.Leong and C. S.Lim (2003), Rapid Prototyping: Principles and applications, 2nd Edition, World Scientific Publishing Co. Pte. Ltd.
2. D. T.Pham and S. S.Dimov (2001), Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, 1st Edition, Springer-Verlag

London Limited.

REFERENCES:

1. Andreas Gebhardt (2003), Understanding Additive Manufacturing: Rapid Prototyping · Rapid Tooling · Rapid Manufacturing, Hanser Publications.
2. Fuewen Frank Liou (2007), Rapid Prototyping and Engineering Applications, 2nd Edition, CRC Press.
3. Ali K. Kamrani, Emad Abouel Nasr (2006), Rapid Prototyping: Theory and Practice, 6th Edition Springer Publications.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4709**					
TITLE OF THE COURSE	**DESIGN FOR MANUFACTURING**					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of materials in additive manufacturing for various advanced process.
- Impart the knowledge on design considerations for designing components produced using various machining operations like turning, drilling, milling, grinding etc.
- Design the parts cut to length and screw machine parts of various processes, open and closed die forging
- Educate the students on design rules and recommendations for processes like Machining, metal casting, metal joining, forging, extrusion, & powder metallurgy
- Describe the different types of manufacturing systems and compare their suitability for economic production of various components and products

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the principles of manufacturability and design for manufacture.	L2

CO2	Outline the appropriate design for economical production and select the materials.	L1
CO3	Select proper materials and manufacturing processes for designing products and components by applying the relevant principles for ease and economic production.	L4
CO4	Apply a systematic understanding of knowledge in the field of metal casting and forging	L3
CO5	Perform design guidelines and background for powder metallurgy parts and reviewing of for metal parts	L5

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO DESIGN FOR MANUFACTURING	**09Hrs**
Material and process selection – Introduction, Advantages of applying DFMA, General requirements of early materials and process selection, Selection of Manufacturing processes, Selection of materials. Engineering Design features. – Dimensioning, Tolerances, General Tolerance, Geometric Tolerances, Assembly limits, achieving larger machining tolerances, Datum features.	
MODULE 2: DESIGN CONSIDERATIONS IN MACHINING	**09Hrs**
Over view of various machining processes. General design rules for machining, Dimensional tolerance and surface roughness, Design for machining ease, Redesign of components for Machining ease with suitable examples, General design recommendations for machined parts.	
MODULE 3: DESIGN CONSIDERATIONS IN METAL CASTING & METAL JOINING	**09Hrs**
Metal casting: Appraisal of various casting processes; selection of casting process, general design considerations for casting, casting tolerances, use of solidification simulation in casting design, product design rules for sand casting Metal joining: Appraisal of various welding processes, factors in design of weldments, general design guidelines, pre and post treatment of welds, effects of thermal stresses in welded joints, design of brazed joints	
MODULE 4: DESIGN CONSIDERATIONS IN FORGING & EXTRUSION	**09Hrs**
Forging: Design factors for forging, closed die forging, design parting lines of dies, drop forging die design, General design recommendations. Extrusion: Sheet metal work and plastics, Design guide lines for extruded sections, Design principles for punching, blanking, bending, deep drawing, Keeler -Goodman formability diagram,(forming limit diagram) Component design for blanking,	
MODULE 5: DESIGN CONSIDERATIONS IN POWDER METALLURGY	**06Hrs**
Powder metallurgy processing, stages, compaction characteristics, Tooling, Sintering, Dedicated Dies for compaction, Design guidelines,	

TEXT BOOKS:

1. A K Chitale and R C Gupta, "Product Design and Manufacturing", PHI, New Delhi, 2003.
2. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.

REFERENCES:

1. George E Deiter, "Engineering Design", McGraw Hill International, 2002.
2. Boothroyd G, "Product design for Manufacture and Assembly", First Edition, Marcel Dekker Inc, New York, 1994.
3. Surender Kumar, Goutham Sutradhar, ''Design and Manufacturing", Oxford & IBH Publishing co, Pvt Ltd, 1998.

SEMESTER	**VII**					
YEAR	**IV**					
COURSE CODE	**19ME4711**					
TITLE OF THE COURSE	**OPERATIONS MANAGEMENT**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The objectives of the Course are:

- To understand the concepts of Operation Management and its applications in industrial situations and to familiarize the students with various concepts of Operation Planning and Management
- To enable the students to evaluate the technical feasibility, financial viability, market acceptability and social desirability of projects.
- To understand the concept of project and steps in project management.
- To enable the students to prepare business proposals.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solving problems regarding project management and to develop team work in industrial situations	L3
CO2	Determine performance measures for project evaluation and management	L3
CO3	Work in teams to complete projects or case studies	L4
CO4	Have a knowledge of feasibility & evaluation issues	L2
CO5	Analyze the decision-making process and diagnose potential pitfalls	L4

COURSE CONTENT:	
MODULE 1	**8Hrs**
Need, History, System, Types, functions, characteristics, importance of modern project management – An Integrated Approach – Project Portfolio Management System – Choosing the appropriate Project Management structure - Organizational considerationsstructure and culture, project considerations – steps in defining the project – project Rollup – Process breakdown structure – Responsibility Matrices – External causes of delay and internal constraints.	
MODULE 2	**8Hrs**
Opportunity studies, pre-feasibility studies, feasibility study, functional studies, support studies, components of project feasibility studies – Managing Project resources flow – project planning to project completion, Pre-investment phase, Investment Phase and operational phase – Project Life Cycle – Project constraints.	
MODULE 3	**10Hrs**
Net Present Value (Problems - Case Study), Benefit Cost Ratio, Internal Rate of Return, Urgency, Payback Period, ARR – Project Evaluation under uncertainty – Methodology for project evaluation – Commercial vs. National Profitability – Social Cost Benefit Analysis. Computer applications-selection of software packages for applications to project management.	
MODULE 4	**8Hrs**
Developing the project network – constructing a project network (Problems) – PERT – CPM – crashing of project network (Problems - Case Study), network analysis for monitoring the project, resource leveling and resource allocation – how to avoid cost and time overruns – Steps in Project Appraisal Process – Project Control Process – control issues – project audits –process – project closure – team, project manager evaluations.	
MODULE 5	**8Hrs**
Managing versus leading a project - managing project stakeholders – social network building (Including management by wandering around) – qualities of an effective	

project manager – managing project teams – Five Stage Team Development Model – Situational factors affecting team development – project team pitfalls. Project Audit and closure.

TEXTBOOKS:

1. Clifford F. Gray and Erik W. Larson, Project management – The Managerial Process, Fourth Edition, Tata McGraw Hill, 2011.
2. Gopalakrishnan P and Ramamoorthy, V.E., Project Management, Macmillan
3. Gary R Heerkens, Project Management, McGraw-Hill, 2002.

REFERENCES:

1. Prasanna Chandra, Projects: Planning, Analysis, Selection, Implementation and Review, 4th Edition, Tata MC Graw Hill, 1995..
2. Harold Kerzner, Project Management: A systems approach to planning, scheduling and controlling, Wiley, 2012.
3. Gregory M. Horine, Project Management Absolute Beginner's Guide (3rd Edition), 2012.

VIII SEM - MECHANICAL ENGINEERING

SEMESTER	**VIII**					
YEAR	**IV**					
COURSE CODE	**19ME4801**					
TITLE OF THE COURSE	**MAJOR PROJECT PHASE – II**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	**-**	**-**	20	240	10

COURSE OBJECTIVES :

- The main objective of the Project Work is for the students to learn and experience all the major phases and processes involved in solving "real life engineering problems".

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students must have acquired: • System integration skills • Documentation skills • Project management skills • Problem solving skills	L3

GENERAL SUGGESTIONS AND EXPECTATIONS
The project work shall be spread over in B.Tech VII semester and B.Tech VIII semester. The project work shall be somewhat innovative in nature, exploring the research bent of mind of the student. A project batch shall comprise of not more than four students. The project work shall be evaluated for 100 marks out of which 100 marks for internal evaluation and 100 marks for end-semester evaluation. The Departmental Committee (DC) consists of HOD, Supervisor and two senior experts in the department. The committee monitors the progress of Project Work. The DC is constituted by the Principal on the recommendations of the department Head. A candidate will continue the Project Work in B.TechVIII semester (Stage - II) and submit a Project report at the end of Stage - II after approval of the Departmental Committee. During Stage - II, the teams shall submit status report in addition to oral presentation before the DC. The DC shall evaluate the project for internal marks based on the

progress, presentations and quality of work.
The report generally contains:

- Cover
- Title page
- Certificate(s)
- Acknowledgements
- Abstract
- Contents page
- List of figures or Tables
- Introduction
- Literature survey
- Methodology
- Results and Discussion
- Conclusion and scope of future work.
- Reference list / Bibliography
- Appendices.

Avoiding plagiarism

1. Plagiarism is taking the words, theories, or ideas of another person and passing them off as your own.
2. Plagiarism can be copying inadvertently/advertently a passage from a book or journal or pasting something from the internet into report without referencing the original source.
3. Plagiarism can also result from wrong referencing.

Avoiding plagiarism

The guide/supervisor shall certify that the report is checked for plagiarism and is within 25% of the content. The project work shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the candidate has executed. It is expected that students should refer national and international journals, proceedings of national and international seminars. Emphasis should be given to the introduction to the topic, literature review, and scope of the proposed work along with some preliminary work/experimentation carried out on the thesis topic. Student should submit the project work covering the content discussed above and highlighting the features of work to be carried out in the work. Student should follow standard practice of thesis writing. At the end of successfully finishing the work he/she has to submit a detailed report and has to present for a viva–voce.

Every candidate doing B.Tech. shall be encouraged to send a paper for publication in a journal or a conference - preferably a concept paper related to their topic highlighting their contribution and the results of their work. An acknowledgement from the Supervisor for having communicated to the journal or conference shall be attached to the report of the Project Work.

SEMESTER	**VIII**					
YEAR	**IV**					
COURSE CODE	**19ME4802**					
TITLE OF THE COURSE	**Tribology and Bearing Design**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

- Understand the steps involved in fundamentals of tribology
- Able to know how to use the technology to gather and analyze data for bearings applications
- Identify different types of bearings and lubrication and examine the applications and troubleshoot problems
- Provide a broad based and discipline mechanism learning concept for tribology.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Learning basic and fundamental skills for tribological analyses	L2
CO2	Appreciation the importance of tribology and extending product life of bearings.	L3
CO3	Methodologies of design and troubleshooting tribological and EHL systems	L3

COURSE CONTENT:	
MODULE 1	**08Hrs**
Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.	
MODULE 2	**08Hrs**
Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restricters, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.	

MODULE 3	08Hrs
Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.	
MODULE 4	**08Hrs**
Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. Antifriction bearings- Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.	
MODULE 5	**10Hrs**
Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems, EHL Contacts- Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution.	

TEXT BOOKS :

1. Mujamdar. B.C., Introduction to Tribology of Bearing, Wheeler Publishing, New Delhi 2001
2. Radzimovsky, Lubrication of Bearings - Theoretical principles and design The Oxford press Company, 2000.

REFERENCES :

1. Dudley D.Fulier., Theory and practice of Lubrication for Engineers, New York Company.1998
2. Moore. Principles and applications of Tribology, Pergamon press, 1975.
3. Pinkus 'O' Stemitch., Theory of Hydrodynamic Lubrication.
4. Stachowiak, G. W, Batchelor, A W., Engineering Tribology, Elsevier publication 1993.
5. Butterworth. Hydrostatic and hybrid bearings, 1983.

SEMESTER	**VIII**					
YEAR	**IV**					
COURSE CODE	**19ME4803**					
TITLE OF THE COURSE	**PLASTIC PROCESSING TECHNOLOGY**					
	Lecture	Tutorial	Practical	Seminar/Projects	Total	Credits

Scheme of Instruction	Hours	Hours	Hours	Hours	Hours	
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The objectives of the Course are to

- Elaborate the fundamentals of plastics including their development and compounding technology.
- Understand the various processing techniques of plastic materials
- Learn the basic processing of thermoplastics by injection molding and extrusion
- Learn the fundamentals and compression and transfer moulding of thermoset plastics.
- Provide a wide knowledge on various secondary processing techniques of plastics

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the concept of processing and effect of rheology in polymer processing of various polymers.	L2
CO2	Illustrate the basic principle and its process parameters of injection moulding technique	L3
CO3	Interpret the processing parameters to obtain good quality of extruded products.	L3
CO4	Analyze the compression and transfer moulding process along with their parameter and process control	L4
CO5	Classify the different secondary/recycling processing techniques of plastics	L2

COURSE CONTENT:

MODULE 1: INTRODUCTION **09Hrs**

Basic Principles of Melt Processing of Thermoplastics – Effect of Polymer Properties on Processing - Thermal Behavior of Polymer Melt, flow behavior of polymer melts - Rheology of Ideal Fluids and Polymers, Different Types of Processes and Limitations - Processing advantage of Plastics over conventional Materials and different grades of plastics.

MODULE 2: INJECTION MOULDING PROCESS **08Hrs**

Basic Process Principles, Machine rating and Specifications - Types of Machines –injection moulding operation- theoretical concepts and their relationship to processing- Shrinkage – Annealing - Dimensional Control - Moulding Records - Trouble Shooting – handling of finished products

Injection Moulds: Types of Injection Moulds - Two Plate Mould - Three Plate Mould - Cavity & Core finishing – Gate Types - Runners – Hot Runner Moulds –Insulated Runner Mould

system.	
MODULE 3: EXTRUSION	**08Hrs**
Introduction - principles - classification of extruders –drive mechanism - single screw extruder- specification - screw nomenclature - types of screws - L/D ratio, compression ratio-backpressure - factors governing back pressure - output and factors affecting output. Twin screw extruder - principle - types - process - merits & demerits - Vented barrel extruder -hopper loading devices - Drying equipments - Process, machinery - downstream equipments- - dies for producing products such as - film - blow film, cast film - Sheets - Tubes and pipes, corrugated pipes - Mono filaments - Box strapping - Wire & Cable Coating.	
MODULE 4: COMPRESSION MOULDING & TRANSFER MOULDING	**09Hrs**
Principle – Process - Machine Specification - Material Recommendation and flow properties – Bulk factor - Moulding powders - Preforms & Preheating Techniques - Process Variables –Moulding of Thermoplastic & Thermoset Material, Finishing of moulding Principles of transfer moulding-advantages over compression moulding-Equipment Used-Types of Transfer moulding, Moulds, Press Capacity-Integral moulds and auxiliary ram moulds-Moulding cycles-Tool costs-Moulding tolerances - Materials Theoretical calculation of pressures-Line pressures- Injection ram pressure-clamping-Heating requirements-Finishing of moulded parts -Moulding faults - causes and remedies.	
MODULE 5: SECONDARY PROCESSING TECHNIQUES	**08Hrs**
Powder coating, casting, machining & joining of plastics-Decoration of Plastics-Metalizing-Printing & Painting -Post moulding operations techniques, In mould labelling. Plastics waste management- Basic principles-mechanical recycling-chemical recycling-incineration, Pyrolysis -mixed waste recycling-value addition, application and development for recycled materials	

TEXT BOOKS:

1. A. Brent Strong (2005), Plastics: Materials and Processing, 3rd Edition, Pearson Publications.
2. P.N. Baker, W.S. Allen (2004), Handbook of Plastic Technology Plastic Processing Operations: Injection, Compression, Transfer and Blow Moulding, Volume 1, CBS Publishers & Distributors Pvt. Ltd.

REFERENCES:

1. M. Joseph Gordon Jr. (2010), Total Quality Process Control for Injection Molding, 2nd Edition, Willey Publications.
2. Bruce A. Davis (2003), Compression Molding, Hanser Publications.
3. Michael L. Berins (1991), SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc., 1st Edition Springer Publications.

SEMESTER	**VIII**
YEAR	**IV**
COURSE CODE	**19ME4804**
TITLE OF THE	**AUTOMOBILE ENGINEERING**

COURSE						
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	

COURSE OBJECTIVES:

The course will enable the students to:

- Understand basics of Automobile Engineering & various Automotives system.
- Understand vehicle layout, vehicle specifications & important of automobile.
- Make the student conversant with drive train & transmission.
- Make the student conversant with Suspension, Steering, Brakes systems & Tyre Wheel assembly.
- Make the student conversant with Vehicle Maintenance & Garage Practice.
- Understand the various Automobile Electrical Systems, Vehicle performance & their safety.

COURSE OUTCOMES:		
CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	The student would be able to handle technical & management problems in automotive industries	
CO2	Diagnosis the faults of automobile vehicles.	
CO3	Describe how the steering systems operate.	
CO4	Understand the environmental implications of automobile emissions	
CO5	Develop a strong base for understanding future developments in the automobile industry	

COURSE CONTENT:	
MODULE 1 Introduction to Automobile Engineering	
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2 Drive Train & Transmission	

Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor,Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.
MODULE 3 Front & Rear Axle & Steering System
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers
MODULE 4 Vehicle Performance, Safety & Modern Trends
Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise
MODULE 5 Electrical System & Vehicle maintenance
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.

TEXTBOOKS:

1. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.
2. Automobile Electrical Equipment -P. S. Kohali, Tata McGraw Hill Publishing House

REFERENCES:

1. Narang G. B. S , " Automobile Engineering", S. Chand and Company Ltd
2. Dr.Kirpal Singh, "Automobile Engineering",Volume 1,Standard Publishers distributors

SEMESTER	**VIII**					
YEAR	**IV**					
COURSE CODE	**19ME4805**					
TITLE OF THE COURSE	**FUELS AND COMBUSTION**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

- To understand basics of solid, liquid and gaseous fuel properties, analysis, process and handling
- To understand basics of stoichiometry relations.
- To understand Phenomenon of the combustion process
- make student conversant with features of different types of burners

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	The student will be able to differentiate between various fuels	
CO2	analyze exhaust and flue gases	
CO3	Understand design considerations of burners	
CO4	Control of emissions in combustion	
CO5	Understanding of the air and fuel induction processes	

COURSE CONTENT:	
MODULE 1 Fuels	
Solid fuels – Classification, preparation, cleaning, analysis, ranking and properties – action of heat, oxidation, hydrogenation, carbonization, liquefaction and gasification.Liquid fuels – Petroleum – origin, production, composition, classification, petroleum processing, properties, testing – flow test, smoke points, storage and handling.Secondary liquid fuels – Gasoline, diesel, kerosene and lubricating oils. Liquid	

fuels – refining, cracking, fractional distillation, polymerization. Modified and synthetic liquid fuels. ASTM methods of testing the fuels.
MODULE 2 Gaseous fuels
Gaseous fuels – Types, natural gas, methane from coal mine, water gas, carrier gas, producer gas, flue gas, blast furnace gas, biomass gas, refinery gas, LPG – manufacture, cleaning, purification and analysis. Fuels for spark ignition engines, knocking and octane number, anti knock additives, fuels for compression, engines, octane number, fuels for jet engines and rockets.
MODULE 3 Combustion
Combustion: Stochiometry, thermodynamics. Nature and types of combustion processes – Mechanism – ignition temperature, explosion range, flash and fire points, calorific value, calorific intensity, theoretical flame temperature. Combustion calculations, theatrical air requirements, flue gas analysis, combustion kinetics – hydrogen – oxygen reaction and hydrocarbon – oxygen reactions.
MODULE 4 Properties and rating of fuels
chemical energy of fuels, Reaction Equation, Properties of A/F mixture,combustion temp, combustion charts, Lead free gasoline's, low and ultra – low sulphur diesels, LPG, CNG,Alcohols, Biodiesels, Gaseous Fuel Injections, Dual Fueling and Controls – CNG and Gasoline, Hydrogenand Diesel, Alcohols and Diesels etc.ENGINE PERFORMANCE: Performance parameters BHP, FHP, IHP, specific fuel consumption,volumetric efficiency, Thermal efficiency, heat Balance sheet, Testing of Engines, Numerical problems
MODULE 5 Initiation of combustion
Initiation of combustion, flame velocities, effect of variables on flame propagation, normal and abnormalcombustion, knocking combustion. Various stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl, squish,tumble flow, velocities, swirl measurement, and delay period correlations, diesel knock and enginevariables

TEXTBOOKS:

1. Fuels and Combustion, Samir Sarkar, Orient Longman Pvt. Ltd, 3rd edition, 2009
2. An introduction to combustion: Concept and applications – Stephen R Turns, Tata Mc. Graw Hill, 3rd edition, 2012.

REFERENCES:

1. Fundamentals of Combustion, D P Mishra, 1st edition, University Press, 2010
2. Engineering Chemistry – R. Mukhopadhyay and Sriparna Datta, Newage International Pvt. Ltd, 2007.