DAYANANDA SAGAR UNIVERSITY

ShavigeMalleshwara Hills, Kumaraswamy Layout,

Bengaluru - 560078, Karnataka.

SCHOOL OF ENGINEERING

SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2020

MECHANICAL ENGINEERING

(3rd to 6th Sem)

(WITH EFFECT FROM 2020-21)

SCHEME - B.TECH – 2020-21 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	20ME2301	COMPLEX VARIABLES AND NUMERICAL METHODS	CR	03	01	--	--	04	*	***
2	105	20ME2302	ENGINEERING MATERIALS	CR	03	--	02	--	04	*	***
3	105	20ME2303	ENGINEERING MECHANICS	CR	03	--	--	--	03	*	***
4	105	20ME2304	THERMODYNAMICS	CR	03	--	--	--	03	*	***
5	105	20ME2305	COMPUTER AIDED MACHINE DRAWING	CR	02	--	04	---	04	*	***
6	105	20ME2306	MECHANICAL MEASUREMENTS	CR	03	--	02	--	04	*	***
7	105	20ME2307	SPECIAL TOPICS – I	CR	01	--	02	--	02	*	***
					18	**01**	**10**	**-**	**24**		

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

SCHEME - B.TECH – 2020-21 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	20ME2401	APPLIED THERMODYNAMICS	CR	02	01	02	--	04	*	***
2	105	20ME2402	MECHANICS OF MATERIALS	CR	02	01	--	--	03	*	***
3	105	20ME2403	FLUID MECHANICS AND MACHINES	CR	03	--	02	--	04	*	***
4	105	20ME2404	MANUFACTURING PROCESS	CR	03	--	02	--	04	*	***
5	105	20ENC001	ECONOMICS FOR ENGINEERS	CR	02	--	--	--	02	*	***
6	105	20ME2405	SPECIAL TOPICS – II	CR	01	--	02	--	02	*	***
					13	**02**	**08**	**--**	**19**		

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

SCHEME - B.TECH – 2020-21 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	20ME3501	HEAT TRANSFER	CR	03	--	02	--	04	III	20ME2304
2	105	20ME3502	KINEMATICS & THEORY OF MACHINES	CR	03	01	--	--	04	*	***
3	105	20ME3503	DESIGN OF MACHIN ELEMENTS – I	CR	02	01	02	--	04	IV	20ME2302
4	105	20ME3504	MANUFACTURING TECHNOLOGY	CR	03	--	02	--	04	*	***
5	105	20ME35XX	PROFESSIONAL ELECTIVE – I	CR	03	--	--	--	03	*	***
6	105	20OEXXXX	OPEN ELECTIVE – I	CR	03	--	--	--	03	*	***
7	105	20ME3505	SPECIAL TOPICS – III	CR	02	--	--	--	02	*	***
					19	**02**	**06**	**--**	**24**		

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

PROGRAM ELECTIVE – I			
SL.NO	**COURSE CODE**	**COURSE TITLE**	**Group**
1	20ME3506	INTRODUCTION TO ROBOTICS AND AUTOMATION	ROBOTICS & AUTOMATION
2	20ME3507	FUNDAMENTALS TO MACHINE LEARNING & ARTIFICIAL INTELLIGENCE	
3	20ME3508	ADDITIVE MANUFACTURING TECHNOLOGY	ADDITIVE MANUFACTURING
4	20ME3509	AUTOMATED MANUFACTURING SYSTEMS	
5	20ME3510	INTRODUCTION TO HYBRID & ELECTRIC VEHICLES	HYBRID & ELECTRIC VEHICLES
6	20ME3511	AUTOTRONICS	
7	20ME3512	REFRIGERATION AND AIR CONDITIONING	GENERAL
8	20ME3513	TOOL DESIGN	

SCHEME - B.TECH – 2020-21 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	20ME3601	DESIGN OF MACHINE ELEMENTS – II	CR	02	01	02	--	04	IV	20ME2402
2	105	20ME3602	FINITE ELEMENT METHODS	CR	02	01	02	--	04	*	***
3	105	20ME3603	MECHANICAL VIBRATIONS	CR	03	--	02	--	04	*	***
4	105	20ME36XX	PROFESSIONAL ELECTIVE – II	CR	03	--	--	--	03	*	***
5	105	20ME36XX	PROFESSIONAL ELECTIVE – III	CR	03	--	--	--	03	*	***
6	105	20OEXXXX	OPEN ELECTIVE – II	CR	03	--	--	--	03	*	***
7	105	20ENC002	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**	**GROUP**
1	20ME3604	DRIVES & CONTROL SYSTEMS	ROBOTICS & AUTOMATION
2	20ME3605	ELECTRICAL MACHINES AND POWER SYSTEMS	
3	20ME3606	MATERIALS FOR AM	ADDITIVE MANUFACTURING
4	20ME3607	PROCESSING OF PLASTICS & COMPOSITES	
5	20ME3608	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS	HYBRID & ELECTRIC VEHICLES
6	20ME3609	MODEL-BASED EMBEDDED CONTROL SYSTEM DESIGN	
7	20ME3610	RENEWABLE ENERGY SOURCES	GENERAL
8	20ME3611	PRODUCT DESIGN AND MANUFACTURING	

PROGRAM ELECTIVE – III			
SL.NO	**COURSE CODE**	**COURSE TITLE**	**GROUP**
1	20ME36112	ROBOT KINEMATICS AND DYNAMICS	ROBOTICS & AUTOMATION
2	20ME36113	INDUSTRIAL AUTOMATION-I	
3	20ME36114	COMPUTATIONAL TOOLS FOR AM	ADDITIVE MANUFACTURING
4	20ME36115	MICRO AND NANO FABRICATION TECHNOLOGIES	
5	20ME36116	HEV / EV SYSTEM DESIGN ARCHITECTURE	HYBRID & ELECTRIC VEHICLES
6	20ME36117	MATERIALS AND MANUFACTURING PROCESSES FOR AUTOMOTIVE SYSTEMS	
7	20ME36118	INTERNAL COMBUSTION ENGINES	GENERAL
8	20ME36119	MEMS (MICRO ELECTRO MECHANICAL SYSTEMS)	

SCHEME - B.TECH – 2020-21 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	20ME4701	CONTROL SYSTEMSENGINEERING	CR	03	--	02	--	04	*	***
2	105	20ME47XX	PROFESSIONAL ELECTIVE – IV	CR	03	--	--	--	03	*	***
3	105	20ME47XX	PROFESSIONAL ELECTIVE – V	CR	03	--	--	--	03	*	***
4	105	20OEXXXX	OPEN ELECTIVE – III	CR	03	--	--	--	03	*	***
5	105	20ME4702	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**	**GROUP**
1	20ME4703	INDUSTRIAL AUTOMATION-II	ROBOTICS & AUTOMATION
2	20ME4704	AUTOMATION SYSTEM DESIGN	
3	20ME4705	INDUSTRY 4.0 AND IOT	ADDITIVE MANUFACTURING
4	20ME4706	CAD/CAM FOR AM	
5	20ME4707	VEHICLE DYNAMICS ADVANCED POWERTRAIN	HYBRID & ELECTRIC VEHICLES
6	20ME4708	ADVANCED ENERGY STORAGE	
7	20ME4709	COMPUTATIONAL FLUID DYNAMICS	GENERAL
8	20ME4710	OPERATIONS MANAGEMENT	

PROGRAM ELECTIVE – V			
SL.NO	**COURSE CODE**	**COURSE TITLE**	**GROUP**
1	20ME4711	ROBOT VISION SYSTEMS	ROBOTICS & AUTOMATION
2	20ME4712	ROBOT PROGRAMMING	
3	20ME4713	INTELLIGENT MANUFACTURING SYSTEMS	ADDITIVE MANUFACTURING
4	20ME4714	POWDER METALLURGY MANUFACTURING	
5	20ME4715	POWERTRAIN INTEGRATION IN HEV	HYBRID & ELECTRIC VEHICLES
6	20ME4716	ENERGY MANAGEMENT AND CONTROL STRATEGIES	
7	20ME4717	AUTOMOBILE ENGINEERING	GENERAL
8	20ME4718	TRIBOLOGY AND BEARING DESIGN	

SCHEME - B.TECH – 2020-21 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	20ME48XX	PROFESSIONAL ELECTIVE – VI	CR	03	--	--	--	03	*	***
2	105	20ME4801	MAJOR PROJECT PHASE– II	CR	--	--	--	20	10	*	***
					03	**-**	**-**	**10**	**13**		

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PROGRAM ELECTIVE – VI			
SL.NO	**COURSE CODE**	**COURSE TITLE**	**GROUP**
1	20ME4802	ADVANCED AI FOR ROBOTICS	ROBOTICS & AUTOMATION
2	20ME4803	ROBOT SIMULATION & OFFLINE PROGRAMMING	
3	20ME4804	ADDITIVE MANUFACTURING FOR MEDICAL APPLICATIONS	ADDITIVE MANUFACTURING
4	20ME4805	SUSTAINABLE MANUFACTURING	
5	20ME4806	ADVANCED PROPULSION SYSTEMS FOR HYBRID ELECTRIC DRIVE VEHICLES	HYBRID & ELECTRIC VEHICLES
6	20ME4807	AUTOMOTIVE ELECTRONICS FOR EV'S	
7	20ME4808	FEM- STRUCTURAL MECHANICS APPLICATIONS	GENERAL
8	20ME4809	ORGANIZATIONAL BEHAVIOUR AND PROFESSIONAL COMMUNICATION	

III SEM - MECHANICAL ENGINEERING

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2301**					
TITLE OF THE COURSE	**COMPLEX VARIABLES AND NUMERICAL METHODS**					
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
1	I	-	
2	II		

COURSE OBJECTIVES:

- Understanding basic concepts of Complex variables and Complex integration
- To illustrate its importance through applications to science and Engineering.
- To provide suitable and effective methods called Numerical Methods, for obtaining approximate representative numerical results of the problems.
- Understanding basic concepts of ODE and PDE to illustrate its power and utilitythrough applications to science and Engineering.
- Understanding basic concepts of Probability and Random variables.
- Apply the concepts of Probability distribution in engineering.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyse Complex variables and complex integration	L2
CO2	Study the discrete and continuous random variables	L1
CO3	Analyse various distributions related to discrete and continuous random variables	L3
CO4	Analyse numerically the solution for ODEs	L3
CO5	Analyse numerically the solution for PDEs	L3
CO6	Apply knowledge or Mathematics in Science and Engineering.	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**
COMPLEX VARIABLES Complex function, Limits, Continuity, differentiability, Analytic Functions, CREquations, and Properties of Analytic functions.	

Self-Learning Component : Complex number and its properties	
MODULE 2	**12Hrs**
INTEGRATION IN THE COMPLEX PLANE Complex Integrals, Cauchy -Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their Consequences, Cauchy's Two Integral Formulas, Some Consequences of the Integral Formulas, Applications. Self-Learning Component : Integration and some basic formulae	
MODULE 3	**12Hrs**
PROBABILITY THEORY Random Variable-Discrete and continuous random variables- Distribution and density function-Properties-Binomial Distribution-Poisson Distribution-Uniform Distribution-Gaussian Distribution-Exponential Distribution-Rayleigh Distribution-Conditional Distribution- Multinomial Distribution Density function-Properties Self-Learning Component : Events, Sample space	
MODULE 4	**12Hrs**
NUMERICAL METHODS FOR ORDINARY DITTERENTIAL EQUATIONS 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 Self-Learning Component : First order ODE and its solving techniques	
MODULE 5	**10Hrs**
NUMERICAL METHODS FOR PARTIAL DITTERENTIAL EQUATIONS 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. A First course in complex analysis with applications, Dennis Zill and PatrickShanahan, Jones and Bartlett publishers.
2. A First Course in Probability, S. Ross, Pearson International Edition, 9th Edition
3. Fundamentals of Mathematical Statistics, S. C. Gupta and V. K. Kapoor, Sultan Chand& Sons, 11th Edition
4. Numerical Methods for Engineers, Chapra and Canale, Mc Graw Hill Education, 7thedition

REFERENCES:

1. Complex Variables and applications, Brown and Churchill, Mc Graw HillEducation, Eighth Edition.
2. Probability, Statistics and Statistics with Reliability, Queuing, and ComputerScience Applications, Kishore Trivedi, Prentice Hall, 2nd Edition
3. Probability and Random Processes, S. Miller and Childers, Elsevier Inc., SecondEdition
4. Advanced Engineering Mathematics, E. Kreyzsig, Wiley, 10th Edition
5. A First Course in Numerical Methods, Ascher and Grief, SIAM 2011

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2302**					
TITLE OF THE COURSE	**ENGINEERING MATERIALS**					
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			

COURSE OBJECTIVES:

The objectives of the Course are to

- Describe the difference in atomic/molecular structure between crystalline and non-crystalline materials.
- Describe the tensile, compression, shear and bending deformations of the metalspecimen and to describe the changes in specimen profile up to the point of fracture.
- Determine the various phases present, composition and the mass fractions of thephases from a binary phase diagram.
- 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.
- Familiarize with the testing standards for mechanical characterization

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Classify engineering materials based on their crystalstructure	L2
CO2	Calculate the material properties through testing of materials	L3
CO3	Interpret phase diagram for alloy preparation	L2
CO4	Relate the phase diagram, microstructure and themechanical properties of materials	L3
CO5	Select material for an application by analysing therequirements with the material properties	L1
CO 6	Prepare polymer composites by hand lay-up, vacuumagging, resin transfer moulding and filament winding processes	L3

COURSE CONTENT:	
MODULE 1	**8Hrs**

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.	
MODULE 2	**8Hrs**
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.	
MODULE 3	**10Hrs**
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.	
MODULE 4	**8Hrs**
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.	
MODULE 5	**8Hrs**
Ceramics, Glass Ceramics, Advanced ceramics, Functional properties and applicationsof ceramic materials and Glasses, Polymers, Composites, Nanomaterials, Materials used in additive manufacturing.	

List of Laboratory/Practical Experiments activities to be conducted : 28Hrs
1. 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.
2. 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.
3. Shear Test - To determine ultimate shear strength of aluminium under single and double shear.
4. 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.
5. Impact Test (Charpy and Izod) - To evaluate the energy absorbed during failure of a notched specimen subjected to pendulum impact testing.
6. Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens.
7. Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen.
8. Wear Test - To understand the parameters that affect the wear rate using pin anddisc apparatus.
9. Composite preparation- preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process.
10.Demonstration of 3D printing of given polymer/metal/ceramic specimens.

TEXT BOOKS:

1. William D. Callister, Jr.(2020) "Materials Science and Engineering anIntroduction", 2nd Edition, John Wiley & Sons, Inc.

V. Raghavan (2019), "Materials Science and Engineering", Prentice – Hall of IndiaPvt. Ltd.

2. V. Raghavan (2019), "Materials Science and Engineering", Prentice – Hall of IndiaPvt. Ltd.

REFERENCES:

1. J.M. Shackelford (2014), Introduction to Materials Science for Engineers, 5thEdition, Prentice Hall, Inc.
2. Suryanarayana, A. V. K. (2020), Testing of Metallic Materials, Prentice Hall India,New Delhi.
3. W. Bolton (2013), Engineering materials technology, 3 rd Edition, Butterworth &Heinemann.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2303**					
TITLE OF THE COURSE	**ENGINEERING 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

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
- Explain concepts of friction and their relevance in Engineering problems
- Describe centroid, center of gravity and differences between them, area moment ofinertia, examples of planar objects and computations for them
- Describe Trusses and its classification, assumptions in analysis of trusses, forces inmembers in a truss
- Calculate various dynamic quantities of translational motion and projectile motion
- Explain principles of dynamics in plane motion analysis

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Analyze structure using free body diagrams andprinciple of statics	L3
CO2	Analyze structures using concept of equilibriumconditions considering effect of frictional forces	L3
CO3	Calculate the centroid and moment of inertia ofcomposite geometrical sections	L3
CO4	Compute axial forces in members of determinatetruss	L3
CO5	Analyze plane kinematics and kinetics ofparticles/rigid bodies	L3

COURSE CONTENT:	
MODULE 1	**8Hrs**
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.	
MODULE 2	**8Hrs**
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.	
MODULE 3	**10Hrs**
Centroid, Centre of 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.	
MODULE 4	**8Hrs**
Analysis of Truss: 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.	
MODULE 5	**8Hrs**
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 BOOKS:

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

REFERENCES:

1. R.C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
2. Bansal R.K (2010), A Text Book of Engineering Mechanics, Laxmi Publications.
3. H.J. Sawant, S.P Nitsure(2018), Elements of Civil Engineering and Engineering Mechanics, Technical Publications.
4. www.dsu.edu.in

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2304**					
TITLE OF THE COURSE	**THERMODYNAMICS**					
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

- Introduce basic concepts related to thermodynamic system
- Understand Zeroth law of thermodynamics as basis for temperature measurement.
- Define first law of thermodynamics as applied to closed and open systems.
- Explain working of heat engine and refrigeration cycles and to define second law of thermodynamics: Kelvin Planck and Clausius Statement.
- Understand the property entropy through Clausius inequality.
- Understand behavior of ideal and real gases through equation of state andcompressibility factor.
- Define pure substance and explain salient points involved in phase change,Plot statediagrams for pure substance.

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the basic concepts of thermodynamics	L2
CO2	Apply laws of thermodynamics in temperature measurement, work, heat and other energy interactionsof different systems	L3
CO3	Analyze system performance based on second lawimplications	L4
CO4	Calculate work, heat, change of energy, change of entropy for closed and open systems executing variousthermodynamic processes with and without phase change	L3
CO5	Differentiate between ideal and real gas behavior andexplain the compressibility factor	L2
CO 6	Calculate thermodynamic properties of a puresubstance in a given state	L3

COURSE CONTENT:	
MODULE 1	**10Hrs**

Basic Concepts of Thermodynamics: Introduction- Basic Concepts, Thermodynamic Equilibrium, Thermodynamic 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, 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. compressibilityfactor.	
MODULE 2	**8Hrs**
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	
MODULE 3	**8Hrs**
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 statementof 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.	
MODULE 4	**8Hrs**
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.	
MODULE 5	**8Hrs**
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, T-sdiagrams, dryness fraction, use of steam tables.	

TEXT BOOKS:

1. P.Nag (2017), Basic & Applied Thermodynamics, 2nd Edition, Mc Graw HillEducation.
2. Van Wylen, G.J., and Sonnatag, R.E., (2002), Fundamentals of ClassicalThermodynamics for Engineers, 6th Edition, Wiley.

REFERENCES:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An EngineeringApproach, McGraw Hill Education.
2. Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of EngineeringThermodynamics, John Wiley & Sons Ltd, Chichester.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2305**					
TITLE OF THE COURSE	**COMPUTER AIDED MACHINE DRAWING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**4**	**-**	**84**	**4**

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

COURSE OBJECTIVES:

The objectives of the Course are to

- Provide overview of various CAD software
- Learn basics of sketching features
- Create 3D models using extrude, revolve, draft & other advanced options
- Introduce assembly concepts
- Create simple & complex mechanical assemblies
- Create industrial standard drawings with appropriate views including sectional views

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Discuss different types of CAD tools	L2
CO2	Create 2D geometric sketches by Autodesk FUSION360.	L3
CO3	Develop 3D models of components using basic andadvanced features	L4
CO4	Create different types of assemblies usingappropriate constraints	L3
CO5	Produce BOM and manufacturing drawingsusing appropriate views, symbols & tolerances	L2
CO 6	Discuss applications of CAD data exchange formats	L2

COURSE CONTENT:	
MODULE 1	**10Hrs**
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	**10Hrs**
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	**12Hrs**

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	**12Hrs**

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	**40Hrs**

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 BOOKS:

1. K. R. Gopalakrishna (2017) "Machine Drawing in First angle projection", Subhaspublication, Bangalore.
2. N.D.Bhat & V.M.Panchal (2016), "Machine Drawing", Charotar Publishing House.

REFERENCES:

1. Basant Agrawal & C M Agrawal (2017) "Engineering Drawing, 2nd Edition ",Mc.Grawhill.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2306**					
TITLE OF THE COURSE	**MECHANICAL MEASUREMENTS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**2**	**-**	**70**	**4**

COURSE OBJECTIVES:

The objectives of the Course are to

- Introduce the measurement quantities and measurement standards
- To Study the limits, fits, tolerances and gauges
- 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 systemand terminal systems
- Provide the necessary skills for calibration and testing of different gauges andinstruments.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain measurement standards and system	L2
CO2	Calculate the uncertainty in measurements	L3
CO3	Explain tolerance, limits of size, fits, gauges and the various advancement in laser Interferometers, CMM,Machine Vision Systems	L2
CO4	Describe generalized measurement system highlighting various types of sensors, Identify transducers, signal conditioning components, and different types of presentation devices. measurement of temperature, pressure	L2
CO5	Calibrate various measuring devices and errors and correction factors of various measuring devices	L2
CO 6	Compute the linear and angular measurements and demonstrate the necessary skills to collect data, perform analysis and interpret results to draw validconclusions through standard test procedures.	L2

COURSE CONTENT:	
MODULE 1	**9Hrs**
Standards of Measurements in Meteorology: 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.
MODULE 2 **9Hrs**
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.
MODULE 3 **8Hrs**
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.
MODULE 4 **8Hrs**
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
MODULE 5 **8Hrs**
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.

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs
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 thegiven 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 thegiven 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 wiremethod.
11. Measurements of gear tooth profile using gear tooth Vernier caliper - To Measurethe 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:

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

REFERENCES:

1. S.P. Venkatesh(2008), Mechanical Measurements, ANE Publications
2. Ernest O. Doebelin (2019), Measurement Systems: Application and Design, SIEPublications.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20ME2307**					
TITLE OF THE COURSE	**SPECIAL TOPICS- 1**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	1	**-**	**2**	**-**	**42**	**2**

COURSE OBJECTIVES:

- To Student should be aware with current situation and problems of real world.
- Developing critical thinking
- The gap between the current demand and the conventional teaching can be removed.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Improve their understating more towards real problem.	L2
CO2	Solve the subjective problem using latest availabletechnology.	L3
CO3	Understand different perspective of problem solvingusing software tools	L2
CO4	Prepare documentation for the solution.	L2

COURSE CONTENT:
Online Mooc Courses
Matlab On ramp Certification for basic Matlab.
Mini Project under the guidance of faculty member
Hackathon
Seminar on Mooc courses and project undertaken.

IV SEM - MECHANICAL ENGINEERING

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**20ME2401**					
TITLE OF THE COURSE	**APPLIED THERMODYNAMICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**1**	**2**	**-**	**70**	**4**

COURSE OBJECTIVES :

The objectives of the Course are to

- Understand Gas power cycles like Otto, Diesel, Dual and Brayton cycles and calculationof heat, work interactions and thermal efficiency
- Understand Vapour power cycles and calculation of heat, work interactions andthermal efficiency
- Understand the effect of inlet pressure and temperature on the performance of vapourpower cycles
- Understand the operation of combined cycle with toping gas turbine and bottomingsteam cycle
- Explain the working of a single stage and multistage compressor and to calculate workdone, volumetric-isothermal-polytropic efficiencies
- Understand refrigeration cycle and calculation of COP and to study different types of refrigerants and to appreciate the use of eco-friendly refrigerants
- Study combustion thermodynamics of fuels
- Carry out tests to investigate the performance of internal combustion engines

COURSE OUTCOMES :

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	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	L3
CO2	Calculate the work done and efficiency for single stageand multistage compressor	L3
CO3	Analyze different refrigeration and air-conditioningcycles	L3
CO4	Analyze combustion thermodynamics of fuels	L3
CO5	Estimate the properties of fuels and lubricants likeflash and fire point, viscosity and calorific value.	L2
CO6	Predict I C engine performance parameters at differentoperating conditions and also to carry out heat balance	L3

COURSE CONTENT:	
MODULE 1	**8Hrs**
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	
MODULE 2	**10Hrs**
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	
MODULE 3	**8Hrs**
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	
MODULE 4	**8Hrs**
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	
MODULE 5	**8Hrs**
Combustion Thermodynamics Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs
Determination of Flash point and Fire point of lubricating oil using Abel, Pensky and Marten's (closed) / Cleavland's (Open Cup) Apparatus.
Determination of Calorific value of solid, liquid and gaseous fuels.
Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).

Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal
Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A-F Ratio, heatbalance sheet.

TEXT BOOKS:

1. Kadambi, T. R Seetaraman and K. B Subramanya Kumar (2019), Applications of Thermodynamics, Wiley India Private Ltd, New Delhi.
2. Nag P.K (2017), Basics and applied thermodynamics, Second edition, Tata McGrawHill, New Delhi.

REFERENCES:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An EngineeringApproach, McGraw Hill Education.
2. Michael J. Moran and Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**20ME2402**					
TITLE OF THE COURSE	**MECHANICS OF MATERIALS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**1**		**-**	**42**	**3**

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circlefor plane stress conditions
- Draw shear force and bending moment diagrams in beams to estimate maximumshear forces and bending moment
- Explain torsional moment of resistance, power transmission of straight and steppedshafts, twist in shaft sections
- Explain strain energy due to axial, shear, bending, torsion and impact load
- Explain theories of failure as applied to materials
- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circlefor plane stress conditions

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Calculate stress and strain for different geometriesunder different loading conditions	L3
CO2	Illustrate principal stresses, maximum shearing stress acting on a structural member using analyticaland Mohr's circle method	L2
CO3	Calculate the stresses and strains associated with thin and thick cylindrical pressure vessels under axial andcircumferential loads	L3
CO4	Construct shear force and bending moment diagramsfor statically determinate beams	L3
CO5	Calculate the shear stress for bodies subjected to torsion and bending stresses for columns	L3
CO6	Discuss theories of failure as applied to materials	L2

COURSE CONTENT:	
MODULE 1	**8Hrs**

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.

MODULE 2	**10Hrs**

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.

MODULE 3	**8Hrs**

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.

MODULE 4	**8Hrs**

Torsion

Torsion: Circular shafts, Power Transmission, Torsion of tapered shaft, Shafts inseries andParallel, Thin Tubular and Thin-walled sections.

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

MODULE 5	**8Hrs**

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 BOOKS:

1. Stephen Timoshenko (2002), Strength of Materials, 3rd Edition, CBS Publisher.
2. S. S. Bhavikatti (2017), Mechanics of Solids, New Age International Publications.

REFERENCES:

1. F. P. Beer and E. R. Johnston (2020), Mechanics of Materials, 8th Edition,McGraw Hill publications.
2. R. K. Bansal (2010), A Textbook of Strength of Materials, 4th Edition, LaxmiPublications.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**20ME2403**					
TITLE OF THE COURSE	**FLUID MECHANICS AND MACHINES**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	**2**	**-**	**70**	**4**

COURSE OBJECTIVES:

The objectives of the Course are to

- Define basic properties of fluids and understand the continuum approximation.
- Define kinematics of Fluid Flow
- Describe Lagrangian and Eulerian Approach for fluid flow
- Buckingham's Pi theorem
- Apply dimensional analysis to design new pumps or turbines that are geometricallysimilar to existing pumps or turbines
- To study the performance parameters of Reciprocating , Centrifugal and Gear pumps
- To study the performance parameters of Impulse and Reaction turbines like Peltonwheel turbine, Francis turbine and Kaplan turbine
- Define basic properties of fluids and understand the continuum approximation.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Define fluid, fluid properties and express fluidproperties in terms of various measurable parameters	L1
CO2	Explain fluid dynamics and develop relevant fluid dynamic relations considering continuity, momentumand energy equations, apply the relations for analysis of dynamic forces and flow through variousgeometries	L2
CO3	Apply concepts of dimensional analysis to develop mathematical relations for various fluid flowsituations	L3
CO4	Explain working principles of hydraulic turbomachinery and calculate the power and efficiencies involved in operations of machines andlearn concepts of compressible flow	L2
CO5	Calculate flow rates of fluids using Orifice meter,Venturimeter, Notches, Rotameter, losses in pipe	L3
CO6	Study the performance parameters of Reciprocating , Centrifugal and Gear pumps, Impulse and Reactionturbines like Pelton wheel turbine, Francis turbine	L1

COURSE CONTENT:	
MODULE 1	**8Hrs**
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, pressurevariation in a static fluid, absolute, gauge, atmospheric and vacuumpressures, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid.	
MODULE 2	**10Hrs**
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.	
MODULE 3	**8Hrs**
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.	
MODULE 4	**8Hrs**
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.	
MODULE 5	**8Hrs**
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.	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs
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 BOOKS:

1. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, Wade W. Huebsch (2009)
2. Fundamentals of Fluid Mechanics, John Wiley & Sons Publications.Frank M White (2011),
3. Fluid Mechanics, McGraw-Hill Publication, Seventh Edition

REFERENCES:

1. Jagdish Lal (2016) , Hydraulic Machines, Metropolitian Company book companyLimited
2. Yunus A.Cengel, John M.Cimbala (2006), Fluid Mechanics– Fundamental andApplications, Tata McGraw-Hill Publishing Co. Ltd.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**20ME2404**					
TITLE OF THE COURSE	**MANUFACTURING PROCESS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	**2**	**-**	**70**	**4**

COURSE OBJECTIVES:

Theory component:

- To emphasize the importance of manufacturing sciences in the day-to-day life, and tostudy the basic manufacturing processes.
- 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 identify, discuss, and analyse the manufacturing processes for processing ofplastics.
- 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:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain significance and engineering applications ofvarious casting processes	L1
CO2	Interpret foundry practices like pattern, mold and coremaking required for Casting process	L2
CO3	Differentiate various metal forming processes such asHot and Cold Working, Rolling, Forging, Extrusion and Drawing Processes	L2
CO4	Choose appropriate joining processes for a givenapplication	L3
CO5	Construct different types components using casting,welding and smithy shop	L3
CO6	Explain working principle and engineering applicationsof various manufacturing processes.	L1

COURSE CONTENT:	
MODULE 1	**08Hrs**
CASTINGPROCESS	

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.

MODULE 2	**08Hrs**

METAL FORMING

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.

MODULE 3	**10Hrs**

WELDING PROCESS

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.

MODULE 4	**08Hrs**

POWDER METALLURGY

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.

MODULE 5	**08Hrs**

PROCESSING OF PLASTICS

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.

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs

1. **Foundry shop:** Testing of Moulding sand and Core sand - 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, Foundry Model- Preparation of green sand moulds using two

molding boxes kept ready for pouring- Using patterns (Single piece pattern and Split pattern) & without patterns =
2. **Forging Operations:** Involving upsetting, drawing and bending operations, 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)
5. Industrial Visit- Report making

TEXT BOOKS:

1. P.N. Rao. Manufacturing Technology: Foundry, Forming and Welding, McGrawHill Publication, 5th Edition. (2018)
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes,and Systems, 7th Edition, John Wiley & Sons, Inc, New Jersey. (2019)

REFERENCES:

1. Amitabha Ghosh and Asok Kumar Malik (2010), Manufacturing Science, AffiliatedEast-West Press Ltd.
2. J. T. Black and Ronald A. Kohser (2019) De Garmos Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**20ENC001**					
TITLE OF THE COURSE	**ECONOMICS FOR ENGINEERS**					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	02			**-**	**28**	**2**

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
- Calculate compound interest, effective interest, nominal interest and the inflationvalue
- Draw the cash-flow diagram of a firm, calculate their present worth and equivalentannual worth
- 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 andcyclic replacements

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Explain the relevance of economics in engineeringmanufacturing environment.	L1
CO2	Determine the time value of money	L2
CO3	Determine the present worth and equivalent annualworth of the firm's assets andinvestments.	L2
CO4	Assess the available economic alternatives usingtraditional and discounted cash flowmethods	L3
CO5	Calculate the depreciation value of equipment using different methods	L3
CO6	Perform break-even analysis for a manufacturingcompany	L3

COURSE CONTENT:	
MODULE 1	**04Hrs**
Basic Concepts of Engineering Economics	

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 oftransformation, Concept ofeconomic growth	
MODULE 2	**03Hrs**
Time Value of Money Time value of money - Simple interest, compound interest – nominal interest rate, effectiveinterest rate, and inflation.	
MODULE 3	**07Hrs**
Present Worth and Equivalent Annual-Worth Comparisons Present worth calculations, Equivalent Annual worth Comparison methods, Situationsfor Equivalent Annual worth Comparison, Consideration of asset life, comparison of assets with equal and unequal lives.	
MODULE 4	**07Hrs**
Economic Evaluations 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	
MODULE 5	**07Hrs**
Replacement Analysis and Depreciation 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 BOOKS:

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, PearsonEducation India

REFERENCES:

1. Panneerselvam R, (2013), Engineering Economics, 2nd edition, Prentice HallIndia Learning Private Limited

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**20ME2405**					
TITLE OF THE COURSE	**SPECIAL TOPICS-II**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	01	-	**02**	**-**	**42**	**02**

COURSE OBJECTIVES:

Theory component:

- Student should able to solve real world problem
- Student should be aware with more recent technologies.
- Developing Collaborative Learning, Communication skills.
- Student should be able to solve problems in core and intra/inter/multi-disciplinaryareas.
- Developing critical thinking and communication skills.
- The gap between the current demand and the conventional teaching can be removed.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Improve their understating more towards real problem.	L2
CO2	Solve the subjective problem using latest availabletechnology.	L3
CO3	Understand different perspective of problem solving.	L2
CO4	Understand the subjective application in different inter/intra/multidisciplinary areas.	L2

COURSE CONTENT:
Online Mooc Courses
Matlab On ramp Certification for basic Matlab, Machine learning and Deep Learning.
Mini Project under the guidance of faculty member
Hackathon
Seminar on Mooc courses and project undertaken.

V SEM - MECHANICAL ENGINEERING

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**20ME3501**					
TITLE OF THE COURSE	**Heat Transfer**					
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	20ME2304	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	**20ME3502**					
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	**20ME3503**					
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	III	20ME2302	ENGINEERING 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	**20ME3504**					
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

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	**20EME3505**					
TITLE OF THE COURSE	**Special Topics - III**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**28**	**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	**20ME3506**					
TITLE OF THE COURSE	**INTRODUCTION TO ROBOTICS AND AUTOMATION**					
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 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 paintingoperations.	
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	**V**					
YEAR	**III**					
COURSE CODE	**20ME3507**					
TITLE OF THE COURSE	**FUNDAMENTALS TO MACHINE LEARNING & ARTIFICIAL INTELLIGENCE**					
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, and 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, Analysing 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.
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: Language models, n-grams, Vector space models, Bag of words.
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	20ME3508					
TITLE OF THE COURSE	ADDITIVE 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 additive manufacturing in advance manufacturing process.
- Explore the potential of additive manufacturing in different industrial sectors
- Acquire knowledge, techniques and skills to select relevant additive manufacturing process.
- Apply 3D printing technology for additive manufacturing
- Exploit the technology used in additive manufacturing

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the working principles and process parameters of additive manufacturing processes	L2
CO2	Explore different additive manufacturing processes and suggest suitable methods for building a particular component	L1
CO3	Perform suitable Pre & post processing operation based on product repair requirement	L4
CO4	Design and develop a working model using additive manufacturing Processes	L6
CO5	Able to identify, analyze and solve problems related to Additive Manufacturing	L3

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO ADDITIVE MANUFACTURING	**06Hrs**
Introduction to AM, AM evolution, Historical development, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.	
MODULE 2: ADDITIVE MANUFACTURING PROCESSES	**09Hrs**
Types, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping	

(LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	
MODULE 3: ADDITIVE MANUFACTURING MACHINES AND SYSTEMS	**09Hrs**
Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.	
MODULE 4: PRE-PROCESSING IN ADDITIVE MANUFACTURING	**09Hrs**
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	
MODULE 5: POST-PROCESSING IN ADDITIVE MANUFACTURING	**09Hrs**
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	

TEXT BOOKS:

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
2. Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010

REFERENCES:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
2. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**20ME3509**					
TITLE OF THE COURSE	**AUTOMATED MANUFACTURING SYSTEMS**					
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 provide a comprehensive introduction to industrial automation
- To provide comprehensive introduction of various automation systems and related techniques for programming and system analysis.
- To introduce the modelling methods for the performance analysis and design of automation systems

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Appreciate the relevance of industrial automation.	L2
CO2	Analyze the performance of automated production lines and automated assembly systems.	L3
CO3	Design and draw the functional and logic circuits for the programming of the control elements for automation.	L3
CO4	Understand the role of computer-numerical control and robotics in programmable automation and estimate the effectiveness of programmable automation using cycle time analysis	L4
CO5	Become familiar with the tools and techniques for automated inspection.	L2

COURSE CONTENT:	
MODULE 1: INTRODUCTION	**08Hrs**
Automation in production systems. Fixed, flexible and programmable automation. Principles, reasons and strategies for automation. **Automated systems –** elements, functions, levels of automation. Continuous Vs discrete Control. Product/production relationships, Production concepts and mathematical models, Costs of manufacturing operations.	
MODULE 2: AUTOMATED PRODUCTION LINES AND AUTOMATED	**08Hrs**

ASSEMBLY	
Fundamentals of automated production lines. Applications. Analysis of transfer lines with no internal storage. **Analysis of storage** lines with storage buffers. Fundamentals of automated assembly systems. Design for automated assembly.	
MODULE 3: CONTROL ELEMENTS FOR AUTOMATION	**09Hrs**
Sensors, Sensors position and velocity feedback. Actuators. Servo control. ADC, DAC. Control of electro-hydraulic and electro-pneumatic systems – Fluid-power symbols and Fluid-power control circuits. **Programmable logic controllers** – architecture - Ladder logic diagrams.	
	09Hrs
MODULE 4: PROGRAMMABLE AUTOMATION	
NC and CNC units – Part programming – Direct Numerical control – Adaptive control. Robot anatomy – specifications – ends effectors – applications in manufacturing. Robot cell design and control. Robot cycle-time analysis. Flexible manufacturing systems.	
MODULE 5: AUTOMATED MATERIAL HANDLING AND INSPECTION	**08Hrs**
Automated guided vehicle systems. Automated storage and retrieval systems, carousel storage, and their analysis. Automated inspection systems: Inspection metrology and conventional methods. Coordinate measuring machine. Surface measurement. Introduction to Machine Vision and other optical methods. Non-contact and non-optical inspection techniques.	

TEXT BOOKS:

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition, Pearson, 2016..

REFERENCES:

1. B. Benhabib, Manufacturing: Design, Production, Automation and Integration, New York: Marcel Dekker, 2003.
2. Y. Altintas, Manufacturing Automation, Cambridge University Press, 2nd Edition,2012.
3. J.A. Rehg, Introduction to Robotics in CIM Systems, 5th edition, Prentice Hall, 2003.

SEMESTER	**V**
YEAR	**III**
COURSE CODE	**20ME3510**

TITLE OF THE COURSE	INTRODUCTION TO HYBRID & ELECTRIC VEHICLES					
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

- Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
- Analyze various electric drives suitable for hybrid electric vehicles. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
- Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.	L3
CO2	Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.	L3
CO3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	L3
CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.	L3
CO5	Design and develop the electric propulsion unit and its control for hybrid electric vehicles.	L3

COURSE CONTENT:	
MODULE 1	**8Hrs**

Introduction: State of the Art of HEVs, Challenges and Key Technology of HEVs. Hybridization of the Automobile: Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs). HEV Fundamentals: Introduction, Vehicle Model, Vehicle performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics.	
MODULE 2	**8Hrs**
Plug-in Hybrid Electric Vehicles: Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology. Power Electronics in HEVs: Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics.	
MODULE 3	**10Hrs**
Electric Machines and Drives in HEVs: Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors.	
MODULE 4	**8Hrs**
Batteries, Ultracapacitor, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.	
MODULE 5	**8Hrs**
Integration of Subsystems: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.	

TEXT BOOKS :

1. Husain, I. (2010). Electric and hybrid vehicles: design fundamentals. CRC press.
2. Eshani, M., Gao, Y., Gay, S. E., & Emadi, A. (2005). Modern electric, hybrid electric and fuel cell vehicles. Fundamentals, Theory, and Design. Boca

Raton, FL: CRC.

REFERENCES :

1. Laraminie, J., & Lowry, J. (2003). Electric vehicle technology explained.
2. Chris, M., Masrur, M. A., & Gao, D. W. (2011). Hybrid electric vehicles: principles and applications with practical perspectives. Masrur, David Wenzhong Gap.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**20ME3511**					
TITLE OF THE COURSE	**AUTOTRONICS**					
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

- Learn the basics of electrical and Laws.
- Study about the electrical safety and importance of the earthing.
- Study the construction and principle of DC motor and its types.
- Understand about the generator, alternator, regulator and starting motor and mechanism.
- Study about the different ignition system.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Recognize and understand different wiring diagrams used in manufacturer's workshop manuals.	L3
CO2	Identify the various modules and sensors from the wiring diagrams.	L3
CO3	determine the function and operation of various electronic components	L3
CO4	Understand their role in the management of the vehicle control	L3

CO5	Understand construction and working of different electric and hybrid vehicles.	L3

COURSE CONTENT:	
MODULE 1	**8Hrs**
INTRODUCTION : AUTOMOTIVE ELECTRICAL SYSTEMS : Automotive electric power generation, Storage & Distribution systems, Wiring harness, Circuit diagrams and symbols, 12/24/42 volt system, Positive earth and negative earth, Earth return and insulated return systems, Multiplexed wiring systems, Electromagnetic compatibility, Electromagnetic interference, Controlled Area Networks (CAN) **Battery:** Types, Principle of lead acid battery, Constructional details, Recharging the battery, Battery ratings, Battery Performance, Battery capacities, Battery efficiency, Battery tests, Battery failures, Alkaline battery, Maintenance free batteries, Hybrid batteries	
MODULE 2	**8Hrs**
CHARGING SYSTEMS & REGULATORS : Generators, A. C. Generators, Magnetos Constant current & Voltage systems, Current & Voltage regulator, Semi-conductor type regulator, Regulator for alternators **Starting Systems:** Requirements of Starting system, Starting system layout, Selection of motor, matching battery, Drive mechanisms, Permanent magnet motors	
MODULE 3	**10Hrs**
IGNITION SYSTEMS: Introduction, Types, Lgnition coil, Distributor, Cam angle & Contact angle gap, Advance mechanisms, Ballast Resistance, Limitations of coil Ignition, Transistorized Ignition systems, Spark plugs, types, Construction. **LIGHTING SYSTEMS:** Fundamentals, Headlight, Types, Lighting circuits, Interior lighting, Signaling, LED lighting, Gas discharge lighting	
MODULE 4	**8Hrs**
AUTOMOTIVE EQUIPMETN & ACCESSORIES: Fuel gauge, Oil pressure gauge, Temperature gauges, Speedometer, Warning Lights, Electric Horn, Horn Relay, Wind Shield wipers, Heaters & Defrosters, Electric windows. **AUTOMOTIVE SENSORS & ACTUATORS:** Actuators, Air-flow rate sensor, Angular position sensor, Throttle angle sensor, Temperature sensor, Knock sensor, Pressure sensor. Feedback for engine control, Solenoid actuators, Motorized actuators.	
MODULE 5	**8Hrs**

AUTOMOTIVE ELECTRONIC SYSTEMS: Electronic Ignition systems, Electronic injection systems, Antilock brake system circuit, Traction control, Electronic control of automobile transmission, Active suspension, Engine management system.

ELECTRONIC AND HYBRID VEHICLES : Types, Energy sources – batteries, Fuel cells, Solar and
Hydrogen, Electric machines and controllers, Design considerations, Challenges and recent developments.

TEXT BOOKS :

1. Kohli, P. L. (1983). Automotive electrical equipment. Tata McGraw-Hill Publishing Company.
2. Denton, T. (2017). Automobile electrical and electronic systems. Routledge.

REFERENCES :

1. Ribbens (2013.), "Understanding Automotive Electronics", 7th Edition, Elsevier, Indian Reprint,
2. Tom Denton (2000), "Automobile Electrical and Electronics Systems", Edward Arnold Publishers.
3. Barry Hollembeak (2001), "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**20ME3512**					
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

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 andcalculations; 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, Dhapapatraihill, 1998.

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**20ME3513**					
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.

VI SEM - MECHANICAL ENGINEERING

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3601**					
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	20ME2402	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	**20ME3602**					
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	**20ME3603**					
TITLE OF THE COURSE	**Mechanical Vibrations**					
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	**20ENC002**					
TITLE OF THE COURSE	**LAW FOR ENGINEERS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	**-**	**-**	**-**	**28**	**2**

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

Course Objectives:

The students will be able to

1. Apply the knowledge of the constitutional literacy to become aware of the

fundamental rights and duties in their role as Engineers
2. Understanding of ethical and legal aspects of advertising, consumer problems and their redressal mechanism related to product and service standards.
3. Demonstrate an advanced and integrated understanding of the nature and extent of the corporate entity principle and to understand how this principle applies to corporate groups
4. Critically evaluate the extent and application of the Corporate Law.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand process of ethical and moral analysis in decision making scenarios and inculcate ethical behavior as a trait for professional development.	L1
CO2	Apply the knowledge to solve practical problems with regard to personal issues & business enterprises.	L3
CO3	Identify the conflict management in legal perspective and judicial systems pertaining to professional environment; strengthen the ability to contribute to the resolution of human rights & Ragging issues and problems through investigative and analytical skills.	L2

COURSE CONTENT:	
Module I: Introduction	**08 Hrs**
Introduction to Indian legal system, Review of Constitution of India, Sources of Law and Judicial system. Contracts and its Elements: Employment contracts, Contract Interpretation, service contract , Contract of Indemnity, Law of Agency, Employment Agreement	
Module II : Legal documentation	**08 Hrs**
Legal documentation: Drafting of legal documents including Non-Disclosure Agreements (NDA) , Request for proposal (RFP), Collaboration Agreement , Joint Venture Agreements, Tendering and sub-contracting	
Module III: Property Rules, Trademarks & Copy Rights	**10 Hrs**
Intellectual Property Rules (IPR) Overview, Trademarks , Copy Rights , Patents with special emphasis in Biotechnology Inventions, Software Circuits and Design, Protection in Foreign Countries	
Module IV: Introduction to Labour and Environmental Laws	**08 Hrs**
Labour Laws: Provident Fund, ESIC, Gratuity, Bonus, Perquisites, Contract labour, Health, Safety and welfare of construction workers, Introduction to Environmental Law, Concept of Law & Policy , Environment and Governance ,Sustainable Development and Environment , Understanding Climate Change and its processes – CDP, CDMs and Carbon Off Setting, Overview of International	

Environmental Laws, Introduction to Environment and IPR	
Module V: Cyber Laws & Taxation	**10 Hrs**
Cyber Laws , E-Commerce and E-Governance, Taxation: Income Tax, Service Tax, VAT, Excise Duty, RTI Act.	

Text books:

1. V.S. Datey, Indirect Taxes: Law and Practice, Taxmann Publications (P) Ltd, Latest Edition Publications (P) Ltd, latest Edition.
2. S.C. Srivastava, Industrial Relations and Labour Laws, Vikas Publishing House Pvt.Ltd.
3. Joseph Minatiur, Indian Legal System, Indian Law Institute, New Delhi.

Reference books:

1. Kamith Seth, Computer Internet and New Technology Laws, LexisNexis, First Edition 2013.
2. Prafulla C Pant, The Arbitration and Conciliations Act, 1996, ButterworthsIndia, New Delhi..
3. J. Beatson, Anson's Law of Contract, Oxford University Press.

PROGRAM ELECTIVE – II

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3604**					
TITLE OF THE COURSE	**DRIVES & CONTROL SYSTEMS**					
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 help students to differentiate between Servos and controls.
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range servo and control problems.
- To help students understand the use of different drives and power rating.
- To help students to differentiate between Servos and controls.
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range servo and control problems.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.	L2
CO2	Discuss the concept of transfer functions for the representation of differential equations	L3
CO3	Discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.	L3
CO4	Represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.	L3
CO5	Determine the frequency response techniques for proper servo compensation.	L3

COURSE CONTENT:

MODULE 1 **8Hrs**

ELECTRICAL DRIVES

Electrical Drives: Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives, Choice of Electrical Drives, Status of dc and ac Drives.

Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent Values of Drive Parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, SteadyState Stability, Load Equalization.

Control Electrical Drives: Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives.

MODULE 2 **8Hrs**

SELECTION OF MOTOR POWER RATINGS

Selection of Motor Power Ratings: Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating.

Direct Current Motor Drives: Controlled Rectifier Fed dc Drives, Single Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Single Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Multi quadrant Operation of dc Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of dc Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited dc Motor, Chopper Control of Series Motor.

MODULE 3	**10Hrs**
INDUCTION MOTOR DRIVES Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.	
MODULE 4	**8Hrs**
SYNCHRONOUS MOTOR DRIVES Voltage Source Inverter (VSI) Control, Cyclo-converter Control, Closed Loop Speed Control and Converter Rating for VSI and Cyclo-converter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.	
MODULE 5	**8Hrs**
PERFORMANCE CRITERIA Percent Regulation, Servo System Responses. Servo Plant Compensation Techniques: Dead-Zone Nonlinearity, Change-in-Gain Non-linearity, Structural Resonances, Frequency Selective Feedback, Feedforward Control. Machine Considerations: Machine feed drive Considerations, Ball Screw Mechanical Resonances and Reflected Inertias for Machine Drives.	

TEXT BOOKS :

1 "Industrial Servo Control Systems Fundamentals and Applications", George W. Younkin, 1st Edition, 2003.

2 Fundamentals of electrical drives by G K DUBEY, Narosa publications, 2005

REFERENCES :

1 "Servo Motors and Industrial Control Theory", Riazollah Firoozian, R. Springer, 2nd Edition, 2014.

2 "DC SERVOS Application and Design with MATLAB", Stephen M. Tobin, CRC, 1st Edition, 2011.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3605**					
TITLE OF THE COURSE	**ELECTRICAL MACHINES AND POWER SYSTEMS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**48**	**3**

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

COURSE OBJECTIVES:

The course will enable the students to:

1. To make the students understand the working principle of transducers and sensors.
2. To understand various types of lighting system and charging system..
3. To understand various types of sensors used in engine and application of each sensor.
4. To have a broad knowledge about electrical and electronic components in the vehicle

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To explain various electronic systems present in the vehicle.	L1
CO2	To do demonstrate on quantity of energy conversion through calculations for actual processes	L2
CO3	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
CO4	To explore current trend automotive electronic engine management.	L2
CO5	The student will understand the principle and working of the clutch, gearbox	L1

COURSE CONTENT:	
MODULE 1: BATTERIES AND ACCESSORIES	08hrs
Principle and construction of lead acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on batteries, maintenance and charging	
MODULE 2: STARTING SYSTEM	08hrs
Condition at starting, behaviour of starter during starting, series motor and its characteristics, principle and construction of starter motor, working of different starter drive units, care and maintenances of starter motor, starter switches.	
MODULE 3: CHARGING SYSTEM AND LIGHTING	10 hrs
Generation of direct current, shunt generator characteristics, armature reaction, third brush regulation, cut-out. Voltage and current regulators, compensated voltage regulator, alternators principle and constructional aspects and bridge rectifiers, new developments. Lighting system: insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods – Horn, and wiper system, advances in lighting system (adaptive front lighting system – AFLS).	
MODULE 4 FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS	08 hrs
Current trends in automotive electronic engine management system, electromagnetic interference suppression, electromagnetic compatibility, electronic dashboard instruments, on board diagnostic system, security and warning system.	
MODULE 5 SENSORS AND ACTUATORS	08 hrs
Types of sensors: sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application. Solenoids, stepper motors, relay.Case study of any one of the automotive sensor-based application.	

TEXTBOOKS:

1. Allan Bonnick, “Automotive Computer Controlled Systems”, 2011.
2. Tom Weather Jr and Cland C.Hunter, “Automotive Computers and ControlSystem”, Prentice Hall Inc., New Jersey.

REFERENCES:

1 Santini Al, "Automotive Electricity and Electronics", Cengage Learning, . 2012

2 Tom Denton, "Automotive Electrical and Electronic System", . SAEInternational, 2004.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3606**					
TITLE OF THE COURSE	**MATERIALS FOR ADDITIVE 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.
- Learn the concepts and the role of materials in material design and quality aspects
- Understand the various types of simulation and mathematical models and their practical use
- Utilize material handling equipment in manufacturing situations
- Have wide knowledge on usage of additive manufacturing in various applications

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Determine the appropriate materials for manufacturing process for the product to be made.	L1
CO2	Analyze the suitability of a manufacturing process to convert the raw material to designed specifications.	L4
CO3	Developing the material ability and expertise to apply the latest mathematical tools and techniques for computing and engineering practice.	L5
CO4	Perform cost analysis for various manufacturing process to minimize the cost of processing the material.	L2
CO5	Application of engineering and technological knowledge to solve a wide range of rapid manufacturing problems.	L3

COURSE CONTENT:	
MODULE 1: ROLE OF MATERIALS	**09Hrs**
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Heirarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM	
MODULE 2: MATERIAL DESIGN & QUALITY ASPECTS	**09Hrs**
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).	
MODULE 3: MATHEMATICAL MODELS IN AM	**09Hrs**
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes	
MODULE 4: ADDITIVE MANUFACTURING FOR BIO-MEDICAL DEVICES & OTHERS	**09Hrs**
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods, Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications	
MODULE 5: RAPID MANUFACTURING OBJECTS	**06Hrs**
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.	

TEXT BOOKS:

1. Ian Gibson, David Rosen, and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer, New York, NY, 2015.
2. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

REFERENCES:

4. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
5. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
6. Duc Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer-Verlag London, 2001.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3607**					
TITLE OF THE COURSE	**PROCESSING OF PLASTICS & COMPOSITES**					
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

- Elaborate the fundamentals of plastics and polymer composites including their matrix & reinforcement material.
- understand the various processing techniques of plastic materials
- learn the basic knowledge on machining/joining of plastic materials
- Impart different processing techniques of polymer matrix composites.
- provide a wide knowledge on various secondary processing techniques of polymer composites

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand various kinds of plastics and polymer composite materials.	L2
CO2	Distinguish various processing methods and its process parameters for different plastics	L2
CO3	Interpret the machining/joining properties of different plastics	L3
CO4	Demonstrate the various processing techniques of polymer composites along with their parameter and process control	L2
CO5	Classify the different secondary processing techniques of polymer composites	L2

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO PLASTICS AND COMPOSITES	**08Hrs**
Chemistry and Classification of Polymers – Properties of Thermoplastics – Properties of Thermosetting Plastics – Applications – Merits and Disadvantages. Fibres – Glass, Boron, Carbon, Organic, Ceramic and Metallic Fibers – Matrix Materials – Polymers, Metals and Ceramics	
MODULE 2: PROCESSING OF PLASTICS	**09Hrs**
Extrusion – Injection Moulding – Blow Moulding – Compression and Transfer Moulding – Casting – Thermo Forming. Process parameters, Applications & Limitations	
MODULE 3: MACHINING AND JOINING OF PLASTICS	**08Hrs**
General Machining properties of plastics – Machining Parameters and their effect – Joining of Plastics – Mechanical Fasteners – Thermal bonding – Press Fitting.	
MODULE 4: PROCESSING OF POLYMER MATRIX COMPOSITES	**09Hrs**
Open Mould Processes, Spray-layup, Bag Moulding, Compression Moulding with BMC and SMC –Filament winding – Pultrusion – Centrifugal Casting – Injection Moulding – Reaction injection molding, Autoclaving, Resin transfer molding-Application of PMC's.	
MODULE 5: SECONDARY PROCESSING OF POLYMER COMPOSITES	**08Hrs**
Secondary processing of polymer composites: Joining of polymer composites, Adhesive joining. Mechanical joining, Microwave joining, Induction and resistance welding, Drilling of polymer composites. Conventional vs ultrasonic drilling, Remedies for reducing drilling induce damages, Research tools for secondary processing.	

TEXT BOOKS:

1. A. Brent Strong (2005), Plastics: Materials and Processing, 3rd Edition, Pearson Publications.
2. Frank L. Matthews, R D Rawlings (1999), Composite Materials: Engineering and Science, CRC Press.

REFERENCES:

1. K. K. Chawla (2006), Composite Materials: Science and Engineering, Springer Publications.
2. Akira Kobayashi (1967), Machining of Plastics, 1st edition, McGraw-Hill Publications.
3. Michael L. Berins (1991), SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc., 1st Edition Springer Publications.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3608**					
TITLE OF THE COURSE	**AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

The course will enable the students to:

- To learn the types of chassis and axles.
- To study about the steering system and its methods.
- To understand the suspension systems and its components.
- To learn the functions of universal joint and propeller shafts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To make students familiar with the constructional details of chassis and body.	L2
CO2	The student will understand the principle and working of the Torque Converters	L2
CO3	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
CO4	The student will understand the principle and working of the Hydro-Static Drive and Electric Drives.	L2
CO5	The student will understand the principle and working of the clutch, gearbox	L2

COURSE CONTENT:	
MODULE 1 Chassis & Body	**08Hrs**
Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details.Materials. Testing of vehicles frames., Loads acting on vehicle frame.Integrated body construction, BIW types and	

corresponding design parameters, Vehicle interior system, A, B, & C Pillar.	
MODULE 2 Front Axle And Steering System	**08Hrs**
Types of front axle.Constructions details.Materials. Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering. Steering geometry.Ackerman and Davis steering system. Constructional details of steering linkages. Different types of steering gear boxes. Steering linkages and layouts. Power assisted steering.	
MODULE 3 Clutch and Gear Box	**10Hrs**
Clutch – function – clutch actuating mechanism – Mechanical and hydraulic types – clutch material – single plate dry clutch – dual plate dry clutch – multi plate wet clutch – semi centrifugal and centrifugal clutch – motor cycle clutch – Diaphragm clutch – fluid coupling and torque converter – Trouble shooting of Clutch. Gear Box – purpose – resistance offered to the motion of the vehicle – air resistance – rolling resistance – Resistance offered to the motion of the vehicle – gradient resistance – tractive effort -gear ratio – types of gear boxes – sliding mesh – constant mesh -synchromesh device – epicyclic – over drive – under drive and transfer cases – 4 wheel drive – gear shifting mechanism – floor shifting and steering column shifting – Automatic Gear box (CVT) -Trouble shooting of gear box.	
MODULE 4 Automatic Transmission systems	**08Hrs**
Principle of working of epi-cyclic gear train - Construction and working principle of Ford-T model gear box - Wilson gear box- construction, working and derivation of gear ratios - Cotal electromagnetic transmission - Automatic over-drive - Hydraulic control system for automatic transmission. Chevrolet automatic transmission - Turbo glide transmission - Power glide transmission - Toyota "ECT-i" [Automatic transmission with intelligent electronic control systems] - Mercedes Benz automatic transmission - Hydraulic clutch actuation system for automatic transmission	
MODULE 5 Hydro-Static Drive and Electric Drives	08Hrs
Hydrostatic drive – principle, types, advantages, limitations - Comparison of hydrostatic drive with hydrodynamic drive - Construction and working of typical Janny hydrostatic drive. Lay-out of elective drive - Principle of early and modified ward Leonard control systems – advantages, limitations, performance characteristics	

TEXTBOOKS:

1. Tim Gilles, Automotive Chassis-Brakes, Steering and Suspension, Thomson Delmer Learning, 2005.

2. Heldt.P.M, “Automotive Chassis”, Chilton Co., New York, June 2012.

REFERENCES:

1. Jornsen Reimpell, Helmut Stoll, Automotive Chassis: Engineering Principles, Elsevier, 2nd edition, 2001.
2. Crouse.W.H, Automotive Chassis and Body, McGraw Hill New York, 1971.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3610**					
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**

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

COURSE OBJECTIVES:

The course will enable the students to:

- To educate the students scientifically the new developments in renewable energy studies
- To make understand the new developments in non-conventional and renewable energy studies.
- To emphasize the significance of Green Energy Technologies

COURSE OUTCOMES:

CO No.	Outcomes	Bloom’s Taxonomy Level
CO1	To understand importance of solar energy applications	L1
CO2	To know the principles of power generation by wind energy	L2
CO3	To know ocean energy technologies to harness power	L2

CO4	To appreciate the use of hydrogen as renewable energy source	L3
CO5	Develop capability to do basic design of bio gas plant	L2

COURSE CONTENT:	
MODULE 1 Solar Energy	**10 Hrs**
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting.	
MODULE 2 Wind Energy	**08 Hrs**
Wind Energy- Wind energy - energy chains - application - historical background, merits and 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).	
MODULE 3 Energy from Biomass	**08 Hrs**
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 bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages	
MODULE 4 Tidal, Ocean Thermal Energy, Hydel and Geothermal Energy Conversion	**08 Hrs**
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 - hydel energy: micro hydro - geothermal energy: geothermal energy sources - power plant and environmental issues.	
MODULE 5 New Energy Sources	**08 Hrs**
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

TEXTBOOKS:

1. Rai.G.D, Non- conventional resources of energy, Khanna publishers, Fourth edition, 2010.
2. Khan. B.H, Non-Conventional Energy Resources, McGraw Hill, Second edition, 2009.

REFERENCES:

1. Rao.S & Parulekar, Energy Technology, Khanna publishers, Fourth edition, 2005.
2. Pai.B.R and Ram Prasad.M.S, Power Generation through Renewable Sources of Energy, Tata McGraw Hill, New Delhi, 1991.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME3611**					
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	**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, -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	

PROGRAM ELECTIVE – III

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME36112**					
TITLE OF THE COURSE	**ROBOT KINEMATICS AND DYNAMICS**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES :
• To introduce to the control position and orientation of the tool in the three dimensional space.
• To make the student familiar with the joint variables and the position and the orientation of the tool.
• To discuss about c reating paths for the tool to follow in order to do useful tasks
• To properly regulate the system's high-speed motion.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To control both the position and orientation of the tool in the three dimensional space.	L2
CO2	The relationship between the joint variables and the position and the orientation of the tool.	L2
CO3	Planning trajectories for the tool to follow on order to perform meaningful tasks.	L3
CO4	To precisely control the high speed motion of the system.	L3
CO5		L3

COURSE CONTENT:	
MODULE 1-INTRODUCTION	**10Hrs**
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.	
MODULE 2 DIRECT KINEMATICS	**08Hrs**

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.	
MODULE 3 INVERSE KINEMATICS	**08Hrs**
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.	
MODULE 4 WORKSPACE ANALYSIS AND TRACJECTORY PLANNING	**08Hrs**
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique -continuous path motion, Interpolated motion, straight line motion and Cartesian space teclmique in trajectory planning.	
MODULE 5 MANIPULATOR DYNAMICS	**08Hrs**
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.	

TEXT BOOKS :

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Me Graw Hill Publishing company Ltd., 1995.

REFERENCES :

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993.
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press, 2003.
4. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.
5. Bijay K. Ghosh, Ning Xi, T.J. Tam, Control in Robtics and Automation Sensor -Based integration, Academic Press, 1999.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME36114**					
TITLE OF THE COURSE	**COMPUTATIONAL TOOLS FOR ADDITIVE MANUFACTURING**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**48**	**3**

COURSE OBJECTIVES:

- The primary objective of the course is to give students both a practical and a theoretical knowledge of every stage in the additive manufacturing.
- To provide a broad overview of both hardware and software for additive manufacturing
- To introduce to methods for parametric modeling of solid objects that take into account fabrication constraints.
- To cover optimization methods that are applied to automate the design process and additive manufacturing process.
- To cover latest research work in the field of computational fabrication

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand and use fundamental computer graphics in the context of design and additive manufacturing	L2
CO2	Students will be able to develop geometric models both parametric and organic using computational geometry techniques	L3
CO3	Students will be able to analyze many instances of recent computational fabrication systems that seamlessly blend parametric modeling, slicing and optimization	L3
CO4	In the second part of the semester, students work in groups on large open-ended projects	L1
CO5	Students will be introduced to case studies of latest research papers in the field of additive manufacturing	L2

COURSE CONTENT:	
MODULE 1	**08 Hrs**
Object Transformations: Object Translation, Object Scaling, Object Rotation, Object Reflection, Object Scaling module	
MODULE 2 Geometric Modeling	**08 Hrs**
Hermite Curve Design, Hermite Surface Design, Bezier Curve Design, Bezier Surface Design, B-Spline Curve Design, B-Spline Surface Design, Parametric Design	
MODULE 3 Computational geometry	**10 Hrs**
Convex Hulls: Convexity, The Incremental Algorithm, Analysis of Algorithms, Gift	

Wrapping and Graham Scan, Lower Bound, Divide-and-Conquer; Polygons: Diagonals and Triangulations, Tetrahedralizations, Basic Combinatorics, The Art Gallery Theorem, Scissors Congruence in 2D, Scissors Congruence in 3D; Triangulations: Point Sets, Basic Constructions, Delaunay Triangulations; Voronoi Diagram	
MODULE 4 Optimization Methods	**08 Hrs**
Optimization methods for preprocessing and post processing analysis of geometric models for additive process friendly part builds	
MODULE 5	**08 Hrs**
Case Studies from latest research papers	

TEXTBOOKS:

1. Zeid, I. (1991). CAD/CAM theory and practice. McGraw-Hill Higher Education.

2.

REFERENCES:

1. Kieran, Stephen, and James Timberlake. Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction. New York, NY: McGraw-Hill, 2003. ISBN: 9780071433211.
2. Schodek, Daniel, et al. Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design. New York, NY: John Wiley & Sons, 2004. ISBN: 9780471456360.
3. Schwalbe, M., 2016. Predictive Theoretical and Computational Approaches for Additive Manufacturing: Proceedings of a Workshop.

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME36116**					
TITLE OF THE COURSE	**HEV / EV SYSTEM DESIGN ARCHITECTURE**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**0**	**0**	**-**	**42**	**3**

COURSE OBJECTIVES:

The course will enable the students to:

- Explain the basics of electric and hybrid electric vehicles, their architecture
- Explain hybrid electric vehicle architecture, design and component sizing in hybrid

electric vehicles.

- Analyze various electric drives suitable for hybrid electric vehicles
- Demonstrate different configurations of electric vehicles and its components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals	L1
CO2	Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles	L3
CO3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	L1
CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis	L2
CO5	Understand Energy Management strategies in HEVs	L1

COURSE CONTENT:	
MODULE 1 Design & Engineering – xEV	**08 Hrs**
xEV : micro to mild to PHEV to HEV to REEV to EV - Hybrid-Electric Vehicle Power trains - Vehicle Energy Storage System (VESS) Design - Computational Systems Design (CSD) - Transportation Electrification	
MODULE 2 Introduction to Advanced Electric Vehicles	**08 Hrs**
Fundamentals of xEVs and key challenges and opportunities of AEV technologies - Engineering philosophy of various xEVs (HEV, PHEV and BEV, REEV)	
MODULE 3 Energy Storage Systems	**08 Hrs**
Energy storage systems used; Battery electro-chemistry, battery design and construction, charging and discharging, power density, Battery interface with	

motive source	
MODULE 4 Power Electronics for Electric Vehicles & Energy Conversion	**08 Hrs**
Power electronics including switching, AC-DC, AC-AC conversion, electronic devices and circuits used for control and distribution of electric power Electric Drives / Electromechanical Motors & motive power splitting concepts, and interface within power train system	
MODULE 5 Hybrid Electrical Vehicles	**10 Hrs**
Introduction - System Overview - Power train architecture - Parallel, Series and Combined - Types of xEVs - Vehicle layout and packaging options. - Energy devices & combinations - examples & Case Studies - Environmental Impact - Regulatory Issues (CO_2 gas and particulate emissions) - Duty Cycles in Indian cities; performance (off cycle, durability) - Sustainability assessment; cradle to grave environmental impact.	

TEXTBOOKS:

1. Iqbal Husain, "Electric and Hybrid Vehicles –Design Fundamentals", CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Celll vehicles-Fundamentals - Theory and Design", CRC Press

REFERENCES:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME36117**					
TITLE OF THE COURSE	**MATERIALS AND MANUFACTURING PROCESSES FOR AUTOMOTIVE SYSTEMS**					
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 develop the knowledge of the properties of materials and its alloys
- To introduce the modern materials and alloys.
- To introduce the Surface modification of materials
- To develop knowledge in recent trends in manufacturing techniques of

automobile components

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

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand various materials and its alloys are formed and their classification based on atomic arrangement	L2
CO2	Describe the mechanical behavior of metallic systems and its importance	L3
CO3	Understand the need for modern materials and its alloys.	L3
CO4	Gain knowledge on different class of materials, alloys and their manufacturing techniques, applications in automobile field.	L4
CO5	Understand the need for Recent Trends in manufacturing Auto components.	L2

COURSE CONTENT:	
MODULE 1: Engineering alloys	**08Hrs**
Ferrous alloys-Iron-Iron carbide phase diagram with all phases & critical temperatures-**steel**, Types of steels-Effect of alloying elements on physical and chemical properties-**Automotive applications**- cast iron-Types-properties-factors affecting structures of cast iron-Automotive application. **Non ferrous alloys**- Al, Cu, Tin, Baased alloys, Light metal alloys(mg and Ti)	
MODULE 2: Surface modification of materials	**08Hrs**
Mechanical surface treatment and coating- case hardening and hard facing-thermal spraying-Vapor deposition-ion implantation-diffusion coating-Electroplating and Electro less plating-Conversion coating-Ceramic and Organic coating-Diamond coating-Laser surface treatment-Selection of coating for Automotive applications	
MODULE 3: Modern materials and alloys	**10Hrs**
Super alloys-super plastic alloys for auto body panels-refractory metals-shape memory alloys-dual phase steels-micro alloyed steels-high strength low alloy steels-smart materials -**Composite materials-ceramic** –plastics-introduction, overview of processing, their characteristic features, Types and automotive application-Nanomaterials-Introduction and automotive applications	
	08Hrs
MODULE 4: Engine materials and manufacturing	
Cylinder block and head-cylinder head and gasket-valves, seats and guides-piston and pin-piston ring and liner-con rod-crankshaft and bearing-turbocharger. **Case study**: Engine materials used in 4stroke, 2stroke petrol and diesel engine.	
MODULE 5: Recent Trends in manufacturing Auto components	**08Hrs**

Special processing techniques-Hydroforming-stretch forming-Recent developments in auto body panel forming-squeeze casting of pistons, Aluminium composite brake rotors-sinter diffusing bonded idler sprocket-Gas injection moulding of window channel-Cast con process for auto parts-computer modeling and simulation-material characteristics and failure analysis.	

TEXT BOOKS:

1. Callister W.D. (2006) "Material Science and Engineering- An introduction", Wiley –Eastern
2 Flinn R. A. and Trojan P. K., (1999)"Engineering Materials and their Applications", Jaico.

REFERENCES:

1. Avner S.H., (2006) "Introduction to physical metallurgy" –Tata McGraw Hill..
2. Haslehurst.S.E., " Manufacturing Technology ", ELBS, London, 1990

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20ME36118**					
TITLE OF THE COURSE	**INTERNAL COMBUSTION ENGINES**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	**-**	**-**	**-**	**48**	**3**

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

COURSE OBJECTIVES:

The course will enable the students to:

- To get familiar with the fundamentals of I.C engines, construction and working principle of an engine, and testing of an engine for analysing its performance.
- To study the combustion and its controlling factors in order to design efficient engine
- To study emissions from internal combustion engines and its controlling methods, various emission norms.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student will be able to analyse thermodynamic cycles based on actual conditions.	L3
CO2	Understand operating characteristics of different engine and combustion process for SI and CI engines.	L1
CO3	Understand the different combustion chamber designs and compare for different types fuels used.	L1
CO4	Analyze the emissions in combustion	L3
CO5	Understanding of the various heat transfer mechanisms in the engine	L1

COURSE CONTENT:	
MODULE 1 Basics of Internal Combustion Engines	**08 Hrs**
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 Spark Ignition Engines	**08Hrs**
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, additives.	
MODULE 3 Compression Ignition Engines	**08 Hrs**
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 Combustion Chambers	**08 Hrs**
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 Internal Combustion Engine-System, Emission and Control	**10 Hrs**
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.	

TEXTBOOKS:

1. M. L. Mathur and R. P. Sharma , A course in I.C. Engines, , Dhanpat Rai Pub, 2001.
2. Colin R. Ferguson C,Internal Combustion Engines, John Wiley & sons, 1986

REFERENCES:

1. Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill, 2011
2. V. Ganesan, Internal Combustion Engines, Tata McGraw-Hill, 2012

OPEN ELECTIVE – I

SEMESTER	**V**					
YEAR	**III**					
COURSE CODE	**20OE0015**					
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 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	**20OE0016**					
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,

OPEN ELECTIVE – II

SEMESTER	**VI**					
YEAR	**III**					
COURSE CODE	**20OE0017**					
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	**20OE0018**					
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