DEPARTMENT
OF
MECHANICAL ENGINEERING

SYLLABUS
BACHELOR OF TECHNOLOGY
[2024]

Date of Revision: May-2024

Effective from 1st semester onwards for 2024 admitted batch and 3rd semester onwards for 2023 admitted batch

SMIT SIKKIM MANIPAL UNIVERSITY
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

Sikkim Manipal University

Vision

Global Leadership in Human Development, Excellence in Education and Healthcare

Mission

Develop professionals of excellent technical calibre in the field of Health Sciences, Engineering, Management and Social Sciences with a humane approach capable of shouldering the responsibility of building the nation and be globally competent

Sikkim Manipal Institute of Technology

Vision

To achieve eminence in the field of quality technological education and research

Mission

To develop SMIT into an Institution of Excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society

Mechanical Engineering Department

Vision

To strive for a global centre of excellence and innovation in education, research and entrepreneurship

Mission

To provide holistic education for developing skilled and technically proficient graduates

PROGRAM OUTCOMES

PO 1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9 **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12 **Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1 The Mechanical Engineering Graduates will be able to apply the mechanical principles to specification, fabrication, operation, or documentation of basic mechanical systems or processes and its management.

PSO2 Students will be capable to work in power plants and manufacturing industry in the sphere of operation and maintenance. They will be also able to function in the software industry in the areas of design and development of software tools such as AUTO CAD, Solid works, CATIA.

TABLE OF CONTENT

FIRST YEAR B. TECH CURRICULUM 2024 Onwards (Common to all branches)

(Applicable to students admitted during 2024 and later)

Semester	GROUP A (FIRST SEMESTER) **PHYSICS GROUP**						GROUP B (FIRST SEMESTER **CHEMISTRY GROUP**					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I		Engineering Mathematics–I	3	1	0	4		Engineering Mathematics–I	3	1	0	4
		Elements of Civil Engineering	3	0	0	3		Element of Mechanical Engineering	3	0	0	3
		Engineering Physics	3	1	0	4		Engineering Chemistry	3	1	0	4
		Basic Electronics	3	0	0	3		Element of Electrical engineering	3	0	0	3
		Communication Skills	2	0	0	2		Computer Programming in C	3	1	0	4
		Engineering Graphics	1	0	2	2		Environmental Science	1	0	0	1
		Constitution of India	1	0	0	1		Computer Programming Lab	0	0	2	1
		Workshop Practice	0	0	2	1		Engineering Chemistry Lab	0	0	2	1
		Engineering Physics Lab	0	0	2	1						
			16	2	6	21			16	3	4	21
	Total Contact Hours (L + T + P)					24	Total Contact Hours (L + T + P)					23
II	GROUP A (SECOND SEMESTER)						GROUP B (SECOND SEMESTER)					
		Engineering Mathematics–II	3	1	0	4		Engineering Mathematics–II	3	1	0	4
		Element of Mechanical Engineering	3	0	0	3		Elements of Civil Engineering	3	0	0	3
		Engineering Chemistry	3	1	0	4		Engineering Physics	3	1	0	4
		Element of Electrical engineering	3	0	0	3		Basic Electronics	3	0	0	3
		Computer Programming in C	3	1	0	4		Communication Skills	2	0	0	2
		Environmental Science	1	0	0	1		Engineering Graphics	1	0	2	2
		Computer Programming Lab	0	0	2	1		Constitution of India	1	0	0	1
		Engineering Chemistry Lab	0	0	2	1		Workshop Practice	0	0	2	1
								Engineering Physics Lab	0	0	2	1
			16	3	4	21			16	2	6	21
	Total Contact Hours (L + T + P)					23	Total Contact Hours (L + T + P)					24

Note: UHV–I has been introduced under Mandatory Induction Program.

SECOND YEAR B. TECH CURRICULUM

THIRD SEMESTER						FOURTH SEMESTER					
Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
MA203A1	Engineering Mathematics III	3	1	0	4	MA204A1	Engineering Mathematics IV	3	1	0	4
ME201A1	Thermal Engineering- I	3	1	0	4	ME204A1	Mechanics of Solids- II	3	1	0	4
ME202A1	Mechanics of Solids- I	3	1	0	4	ME205A1	Theory of Machines – I	3	1	0	4
ME203A1	Manufacturing Process	3	1	0	4	ME2XXA3	Program Elective II	3	1	0	4
ME2XXA3	Program Elective-I	3	1	0	4	ME2XXA2	Open Elective-II/Minor	3	1	0	4
ME2XXA2	Open Elective-I/Minor	3	1	0	4	GN201A1	Universal human values-II: Understanding Harmony and Ethical Human Conduct	2	1	0	3
ME201A4	Strength of Materials Lab	0	0	2	1	ME203A4	Computational Lab	0	0	2	1
ME202A4	CAE Lab	0	0	2	1	ME204A4	Manufacturing and Metrology Lab	0	0	2	1
ME201A5	Project Based Learning- I	0	0	2	1	ME202A5	Project Based Learning- II	0	0	2	1
		18	6	6	**27**			17	6	6	**26**
Total Contact Hours (L + T + P)					30	Total Contact Hours (L + T + P)					29

THIRD YEAR B. TECH CURRICULUM

FIFTH SEMESTER						SIXTH SEMESTER					
Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
ME301A1	Thermal Engineering – II	3	1	0	4	BA346A1	Industrial Management	2	0	0	2
ME302A1	Machine Design – I	3	1	0	4	ME305A1	Heat Transfer	3	1	0	4
ME303A1	Theory of Machines - II	3	1	0	4	ME306A1	Machine Design - II	3	1	0	4
ME304A1	Fluid Mechanics & Hydraulic Machines	3	1	0	4	ME3XXA3	Program Elective- IV	3	1	0	4
ME3XXA3	Program Elective-III	3	0	0	3	ME3XXA3	Program Elective- V	3	1	0	4
ME3XXA2	Open Elective-III/Minor/NCC	3	1	0	4	ME3XXA2	Open Elective-IV/Minor	3	1	0	4
ME301A4	Thermal Engineering Lab	0	0	2	1	ME303A4	Machine Dynamics Lab	0	0	2	1
ME302A4	Fluid Mechanics Lab	0	0	2	1	ME304A4	Heat Transfer Lab	0	0	2	1
ME301A5	Project Based Learning- III	0	0	2	1	ME302A5	Mini Project	0	0	2	1
ME301A9	Industrial Training-I	0	0	2	1	GN*****	Quantitative Aptitude and Logical Reasoning - II	1	0	0	1
GN*****	Quantitative Aptitude and Logical Reasoning - I	1	0	0	1						
		18	6	8	**28**	**** Optional Audit Course**		17	5	8	**26**
Total Contact Hours (L + T + P)					32	Total Contact Hours (L + T + P)					30

FOURTH YEAR B. TECH CURRICULUM

SEVENTH SEMESTER						EIGHTH SEMESTER					
Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
ME4XXA2	Open Elective - V/Minor	3	1	0	4	ME4XXA2	Open Elective - VI/Minor	3	1	0	4
	Choice Based Elective	3	0	0	3	ME402A6	Major Project – Phase II	0	0	18	9
ME401A6	Major Project – Phase I	0	0	20	10						
ME401A9	Industrial Training-II	0	0	2	1						
		6	0	22	**18**			3	1	18	**13**
Total Contact Hours (L + T + P)					28	Total Contact Hours (L + T + P)					22

***Industrial Trainings will be conducted during the summer vacations after IV and VI Semester and evaluated in V and VII Semester respectively**

Program Elective - I						Program Elective - II					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
ME201A3	Material Science	3	1	0	4	ME203A3	Manufacturing & Metrology	3	1	0	4
ME202A3	Electric Vehicle Fundamentals	3	1	0	4	ME204A3	Tool Engineering and Design	3	1	0	4
						ME205A3	Internal Combustion Engine	3	1	0	4

Program Elective - III						Program Elective - IV					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
ME301A3	Automobile Engineering	3	0	0	3	ME307A3	Turbo Machinery	3	1	0	4
ME302A3	Advanced Manufacturing Processes	3	0	0	3	ME308A3	Computational Fluid Dynamics	3	1	0	4
ME304A3	Latest Trends in Mechanical Engineering	3	0	0	3	ME309A3	Operation Research	3	1	0	4
ME305A3	Computer Integrated Manufacturing	3	0	0	3						
ME306A3	Computer Aided Design and Manufacturing	3	0	0	3						

Program Elective -V											
Sub. Code	Subject Name	L	T	P	C						
ME310A3	Refrigeration and Air Conditioning	3	1	0	4						
ME311A3	Finite Element Methods	3	1	0	4						
ME312A3	Mechanical Vibration	3	1	0	4						
ME313A3	Production & Operations Management	3	1	0	4						
ME314A3	Power Plant Engineering	3	1	0	4						
ME315A3	Machine Learning	3	1	0	4						

Open Elective - I						Open Elective - II					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
ME201A2	Renewable Energy	3	1	0	4	ME207A2	Energy Management	3	1	0	4
ME202A2	Supply Chain Management	3	1	0	4	ME208A2	Automotive Electrical and Electronics Systems	3	1	0	4
ME203A2	Alternative Fuels and Lubrications for Engines	3	1	0	4	ME209A2	Tribology	3	1	0	4
ME204A2	Composite Materials	3	1	0	4	ME210A2	Flexible Manufacturing System	3	1	0	4
ME205A2	Introduction to Nanotechnology and MEMS	3	1	0	4	ME211A2	Automotive Mechanics for Electric Vehicles	3	1	0	4
ME206A2	Foundations of EV & Hybrid Vehicles							3	1	0	4

Open Elective - III						Open Elective - IV					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
ME301A2	Introduction to Research Publication and Research Ethics	3	1	0	4	ME307A2	Statistical Method for Data Analysis	3	1	0	4
ME302A2	Total Quality Management	3	1	0	4	ME308A2	Financial Planning and Analysis	3	1	0	4
ME303A2	Vehicle Dynamics	3	1	0	4	ME309A2	Automotive Repair and Maintenance	3	1	0	4
ME304A2	Design of Mechanical Systems	3	1	0	4	ME310A2	Fatigue and Fracture	3	1	0	4
ME305A2	Mechatronics	3	1	0	4	ME311A2	Robot Kinematics and Dynamics	3	1	0	4
ME306A2	EV Mechanical Design, Development & Analysis					ME312A2	EV Product Development, Homologation & Hydrogen				

Open Elective - V						Open Elective - VI					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
ME401A2	Personnel Management & Industrial Relations	3	1	0	4	ME404A2	Decision Making Techniques	3	1	0	4
ME402A2	Robotics and Automation	3	1	0	4	ME405A2	EV Data Analytics & Cyber Security	3	1	0	4
ME403A2	EV FEA Analysis	3	1	0	4						

Automotive Engineering [Minor]						Machine Design [Minor]					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
ME201A8	Alternative Fuels and Lubrications for Engines	3	1	0	4	ME203A8	Composite Materials	3	1	0	4
ME202A8	Automotive Electrical and Electronics Systems	3	1	0	4	ME204A8	Tribology	3	1	0	4
ME301A8	Vehicle Dynamics	3	1	0	4	ME303A8	Design of Mechanical Systems	3	1	0	4
ME302A8	Automotive Repair and Maintenance	3	1	0	4	ME304A8	Fatigue and Fracture	3	1	0	4
ME401A8	+MOOC Based	3	1	0	4	ME403A8	+MOOC Based	3	1	0	4
ME402A8	+MOOC Based	3	1	0	4	ME404A8	+MOOC Based	3	1	0	4

Robotics & Automation [Minor]						Advanced Specialization on Electric Vehicles [Mechanical]					
Sub. Code	Subject Name	L	T	P	C			L	T	P	C
ME205A8	Introduction to Nanotechnology and MEMS	3	1	0	4	ME207A8	Foundations of EV & Hybrid Vehicles	3	1	0	4
ME206A8	Flexible Manufacturing System	3	1	0	4	ME208A8	Automotive Mechanics for Electric Vehicles	3	1	0	4
ME305A8	Mechatronics	3	1	0	4	ME307A8	EV Mechanical Design, Development & Analysis	3	1	0	4
ME306A8	Robot Kinematics and Dynamics	3	1	0	4	ME308A8	EV Product Development, Homologation & Hydrogen	3	1	0	4
ME405A8	+MOOC Based	3	1	0	4	ME407A8	EV FEA Analysis	3	1	0	4
ME406A8	+MOOC Based	3	1	0	4	ME408A8	EV Data Analytics & Cyber Security	3	1	0	4

MECHANICAL ENGINEERING
(FIRST YEAR SUBJECTS)

Sub Code: **ME101A1** **Credit: 3 (L-1, T-0, P-2)**

ENGINEERING GRAPHICS

Questions to be set: 05 (All Compulsory)

Course Objective: All graphic forms are very important for communication among engineers in all fields of technology. Engineering graphics is the language used by engineers to transfer ideas and information needed for the construction of technical devices and systems. This course mainly used to develop in students, graphic skills for communication of concepts, ideas and design of engineering products. To expose them to existing national standards related to technical drawings. This course used to introduces students to reading, understanding, and creating engineering drawings. Emphasis is on creating accurate, clear sketches and drawings based on current professional practices. Standards and conventions are presented and their applications.

Pre-requisites: Basic concepts of dimensions, units and its conversion to other units, Polygons, Various shapes of solid.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Increasingly use architectural and engineering scales.
CO2	Demonstrate drafting practices, visualization and projection skills useful for conveying ideas, design and production of components and assemblies in engineering applications.
CO3	Analyse and draw the orthographic projections of points, lines, planes, ands solids
CO4	Generate the sections and development of various engineering components.
CO5	Develop isometric projection, convert orthographic views to isometric views and vice versa for practical engineering problems.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Scales**	In class	Representative fraction, construction of plain scales, diagonal scales and comparative scales	8	1		
	Assignment Topics	Problems solving				
Module 2: **Projections of lines**	In class	Projections of lines in different positions with respect to the reference planes, true length, angle of inclination of lines with reference planes.	7	2, 3		
	Assignment Topics	Problems solving				
Module 3: **Projection of planes and Projection of solids**	In class	**Projection of planes:** Projection of plane lamina of different geometrical shapes in different positions with respect to the reference planes. **Projection of solids:** Projection of solids of different geometrical shapes by change of position method.	7	2, 3		
	Assignment Topics	Problems solving				
Module 4: **Section of Solids and Development of Surfaces**	In class	**Section of Solids:** Section of solids of different geometrical shapes by change of position method. **Development of Surfaces:** Development of parallel lines, Right Prisms, Oblique Prisms, Right Cylinders, Oblique Cylinders, Right pyramids, Oblique Pyramids, Right Cones and Oblique Cones.	7	2,4		
	Assignment Topics	Problems solving				

Module 5: **Orthographic Projection and Isometric Projection**	In class	**Orthographic Projection:** Conversion of pictorial views into orthographic projections of simple machine parts. **Isometric Projection:** Isometric axes, lines, planes and Isometric scale, Isometric Projections of prisms, pyramids, cylinders, cones and simple machine parts	7	2,5		
	Assignment Topics	Problems solving				

Text books:

1. Engineering Drawing by N.D.Bhatt, Charotar Publishing House Pvt.Ltd.
2. Engineering Drawing Vol. I & II, by K. R. Gopalakrishna, Subhas Publications

Reference books:

1. Machine drawing by N.D.Bhatt, Charotar Publishing House Pvt.Ltd.
2. Engineering drawing and computer graphics by M. B. Shah & B.C.Rana, Pearson Education
3. Engineering Graphics by B. Agarwal & C. M. Agarwal, McGrawHill Publication
4. Text book on Engineering Drawing by K.L. Narayana & P. Kannaiah, McGrawHill Publication.

Sub Code: **ME102A1** **Credit: 3 (L-3, T-0, P-0)**

ELEMENTS OF MECHANICAL ENGINEERING

Questions to be set: 05 (All Compulsory)

Course Objective: The objective of this course is to inculcate the basic concepts and principles of mechanical engineering subjects such as thermodynamics, fluid mechanics, I.C Engines, power transmission, welding and machine tools.

Pre-requisites: Knowledge of Physics and Mathematics.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Able to understand the basic concept of Thermodynamics and its application in the field of energy technology.
CO2	Have the concept of different types of IC engines, working of 2 stroke & 4 stroke petrol and diesel engines.
CO3	Able to understand the behaviour of Fluid Flow.
CO4	Able to understand application and working of Belt drives, chain drives. Gear drives and Gear trains (Simple & Compound Gear trains).
CO5	Know about the various machine tools and machining process

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Thermodynamics**	In class	Introduction, systems and surroundings, property, state and process; reversible and irreversible process, cyclic process; heat, work and energy. First law of thermodynamics: energy equations for non-flow and steady flow processes (only equation), limitations of first law, simple calculations. Second law of thermodynamics: statements	8	1		
	Assignment topics	Numerical				
Module 2: **Internal Combustion Engine**	In class	Introduction, classification, Otto and Diesel cycles (no derivation), expression of efficiency, spark ignition and compression Ignition engines, working principles of 4-stroke and 2-stroke cycle engines, numericals	7	2		
	Assignment topics	Working of 2 stroke petrol engine, working of 4 stroke diesel engine, numerical				
Module 3: **Fluid Mechanics**	In class	Introduction- definition of fluid, fluid properties (Density, Sp. weight, Sp. volume, Sp. gravity), Viscosity- dynamic and kinematic, Newton's law of viscosity, different types of fluid. Fluid statics- Statement of Pascal's law, Hydrostatic law (no derivations), fluid kinematics and fluid dynamics (only definition), Numerical	8	3		
	Assignment topics	Numerical				
Module 4: **Transmission of Motion and Power**	In class	Introduction, modes of transmission; belt drive – types of belts, velocity ratio – slip in belt drive (only formula), simple calculations; Gear drive – types of	6	4		

		gears, spur gear nomenclature, simple and compound gear trains – simple calculations.				
	Assignment topics	Numerical				
Module 5: **Metal Cutting and Machine tools**	In class	Welding: Introduction, classification, welding rods and fluxes. Metal Cutting and Machine Tools: Introduction, definition of machine tools, cutting sped, feed and depth of cut. Lathe: Important parts, list of operations performed on a lathe. Drilling Machine: operations on drilling machine.	7	5		
	Assignment topics	Numerical, Principle of Arc and Gas welding				

Text Book:

1. Roy, Hazra Choudhury & Hazra Choudhury- Elements of Mechanical Engineering; Media Promoters and Publishers Pvt. Ltd.
2. Mathur & Domkundwar - Elements of Mechanical Engineering; Dhanpat Rai & Co.

Reference books:

1. Hazra Choudhury & Hazra Choudhury – Elements of Workshop Technology vol. I & II – Media Promoters and Publishers Pvt. Ltd.
2. Gupta – Basic Mechanical Engineering – Dhanpat Rai & Co.
3. Gopalakrishna – Mechanical Engineering Science – Subhash Publications.
4. R. K. Bansal- A Txt Book of Fluid Mechanics and Hydraulic Machine; Laxmi Publications.

Sub Code: **ME101A4** **Credit: 1 (L-0, T-0, P-2)**

WORKSHOP PRACTICE

Course Objective: This course emphasizes on the working of basic conventional machines, models are made by the use of conventional machines/machine tools.

Pre-requisites: Basic concepts of Dimensioning.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Acquire and apply the knowledge of general safety precautions and basic concepts of fabrication processes during preparation of different jobs.
CO2	Identify the basics of carpentry tools and establish hands on experience in fabricating the different carpentry joints with safety precautions.
CO3	Recognize the tools used in plumbing operation and perform some exercises on preparation of external threads in pipes.
CO4	Apply the knowledge of basic fitting to prepare the necessary fit with safety.
CO5	Practice using soldering tools to prepare some joints.

Carpentry: Use of carpentry tools, preparation of joints involving the following operations: planning, chipping, tenoning and mortising. Minimum two models to be prepared; Demonstration of wood working machines

Plumbing: Use of plumber's tools, various pipe fittings, exercises in thread cutting on pipes.

Fitting: Use of fitter's tools; Exercises involving the following operations: measuring and marking, chipping, filing, drilling, tapping, and external threading. Minimum two models to be prepared

Soldering: Use of soldering tools, exercises involving sheet metal joints and electrical circuits/ cable joints.

The broad areas for conduct of experiments are given above. However, the specific list of experiments is as follows. Students are required to perform minimum 12 experiments during semester in the workshop.

List of Experiments:-

1. To perform marking and planning operation on the given wooden piece for making Tee-Dovetail carpentry joint.
2. To perform sawing operation and prepare a Tee-dovetail carpentry joint on the wood piece for making Tee-Dovetail carpentry joint.
3. To perform marking and planning operation on the given wooden piece for making Tee-Bridle carpentry joint.
4. To perform sawing operation and prepare a Tee-dovetail carpentry joint on the wood piece for making Tee-Bridle carpentry joint.
5. To perform cutting and external threading on G.I/PVC pipe.
6. To perform lay out marking on a given mild steel specimen for fitting.
7. To perform filing operation on mild steel specimen for fitting job.
8. To perform hack sawing operation on the given mild steel specimen.
9. To perform drilling operation on given mild steel specimen.
10. To perform tapping operation in given mild steel specimen.
11. To perform soldering on G.I. (Galvanized Iron) sheet to form a lap joint.
12. To perform soldering on G.I. (Galvanized Iron) sheet to form a butt joint.

Reference books:

1. S. K. Hajra Choudhury & Others: Elements of Workshop Technology (Vol. I), MPP.

MECHANICAL ENGINEERING
(HIGHER SEMESTER SUBJECTS)

Sub Code: **MA203A1** **Credit: 4 (L-3, T-1, P-0)**

ENGINEERING MATHEMATICS-III

Questions to be set: 05 (All Compulsory)

Course Objective:
The objective of this paper is to put emphasis on topics like Fourier analysis, Partial Differential equations (PDE), Vector calculus and probability theory. All these topics are very helpful for engineering studies. The concept of gradient, divergence, curl and PDE are required for study of Fluid Mechanics. Fourier series is used to approximate the periodic functions, Fourier transform is used to solve differential equations. In higher studies, to get analytical solution for mathematical problem like integration, system of linear equations (with large number of variables) are not always possible or not so easy. Mechanical Engineers also need to analyze nondeterministic experiments. Probability theory will be useful in achieving this goal.

Pre-requisites: MA10101A, MA10102A

Course Outcomes (CO): This will empower the students to build better understanding related to their problems and enhance the capability of performing critical analysis using mathematical tools contained in the syllabus.

CO	STATEMENT
CO1	Ability to understand fundamentals of Vector Analysis and their application.
CO2	Ability to understand and solve PDE and their application.
CO3	Ability to understand periodic function and Fourier series problem.
CO4	Knowledge on applications of Fourier series/integrals and Fourier transform to solve heat equation.
CO5	Ability to understand Basic probability theory and their applications.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Vector calculus**	In class	Vector-calculus-gradient, divergence and curl , their physical meaning and identities. Line, surface and volume integral, Green's theorem, Divergence theorem Simple applications.	8	1		
	Assignment topics	Stoke's theorems		1		
Module 2: **Partial differential equations**	In class	Definition, degree, order and formation of a PDE. Solution of first order linear PDE. One dimensional wave equation (vibrating string): its derivation and solutions. D' Alembert's solution of wave equation. Derivation of one dimensional heat equation and solution. Solution of two dimensional Laplace's equation.	10	2		
	Assignment topics	Derivation of two dimensional heat equation and solution.		2		
Module 3: **Fourier analysis**	In class	Periodic functions, Fourier series, Fourier series of odd and even functions, functions with arbitrary period, Fourier integrals, Fourier transforms. Convolution theorem.	5	3		
	Assignment topics	Fourier sine and cosine transforms		3		
Module 4: **Application of Fourier series**	In class	Application of Fourier series to forced vibration problems, Parseval's identity : application of Fourier integral and Fourier transform to solve heat equation.	5	4		
	Assignment topics	Fourier transform to solve heat equation		4		

Module 5: **Basic probability theory and applications**	In class	Introduction to Probability: Finite sample space, conditional probability and independence, Baye's theorem, one dimensional random variable, mean, variance and expectation. Distributions: Binomial, Poisson, Uniform.	8	5		
	Assignment topics	Normal Distributions.		5		

Text books:

1. Murray R. Spigel : Vector Analysis, Schaum's Outline Series.
2. Erwin Kreyszig : Advanced Engineering Mathematics, Wiley Eastern.
3. P. L. Meyer, Introduction to Probability and Statistical Applications, Addison-Wesley Publishing Company.
4. I. Sneddon, Elements of Partial Differential Equations, Dover, INC

Reference books:

1. R. K. Jain, S.R.K Iyengar .: Advanced Engineering Mathematics, Narosa.
2. C. E. Weatherburn : Vector Analysis, G Bells & Sons.

Sub Code: **ME201A1** **Credit: 4 (L-3, T-01 P-0)**

THERMAL ENGINEERING-I

Questions to be set: 05 (All Compulsory)

Course Objective: This course emphasizes on the various laws of Thermodynamics and the behavior of pure substances/ Ideal Gases. It also explores the concept of entropy and interaction of heat.

Pre-requisites: Basics knowledge of Heat, work and energy, Laws of Motions, Various gas laws, and knowledge of Element of Mechanical Engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	To apply the knowledge of engineering thermodynamics to model the energy conversion phenomenon.
CO2	To apply the concept of first law of thermodynamics in various steady flow devices.
CO3	To apply the concept second law of thermodynamics in various energy transaction processes.
CO4	Distinguish between ideal gas and pure substance. Calculate and analyze the processes on T-v diagrams to solve advanced engineering problems.
CO5	Able to analyze the working of different power cycles and investigate the performance of systems operating on those cycles.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to thermodynamics**	In class	Units and dimension, system and continuum, scope and limitations of thermodynamics,macroscopic and microscopic point of view, thermodynamic state, properties and cycles, intensive and extensive properties. Zeroth law of thermodynamics: Concept of thermodynamic equilibrium and temperature, temperature scales.	8	1		
	Assignment topics	Numerical questions from Zeroth law of thermodynamics				
Module 2: **Energy Interactions**	In class	Work transfer of different forms, heat transfer – specific heat and latent heat; First law of thermodynamics, closed and open systems, concept of internal energy and enthalpy, specific heats at constant volume and constant pressure, perpetual motion machine of the first kind (PMMI), Steady flow energy equation and its applications.	10	2		
	Assignment topics	Numerical questions from SFEE				
Module 3: **Second law of thermodynamics and Entropy**	In class	Limitations of the first law, heat engines, reversed heat engines andtheir performance, Kelvin-Planck's and Clausius' statements of the second law, reversible and irreversible processes, conditions for reversibility, Carnot cycle and Carnot's theorem, absolute zero temperature. **Entropy**: Clausius' inequality – the property, entropy principle, entropy and disorder, calculation of entropy changes, T-s and h-s diagrams for various processes, concept of third law of thermodynamics. Available and unavailable energy fundamental.	10	3		

	Assignment topics	Available and unavailable energy fundamental.				
Module 4: **Properties of substances**	In class	**Ideal Gases**: Definition, Avogadro's law, internal energy, enthalpy and specific heats and their calculation from simple kinetic theory, entropy changes of ideal gases, Mixing of ideal gases – Dalton's law of partial pressure, evaluation of propertiesof ideal gases. **Pure substance**: Definition, p-v, p-T, T-s and h-s diagrams for pure substances, tabulated properties and process calculations, properties of steam – sensible heat and latent heat, saturation temperature and pressure.	10	4		
	Assignment topics	Mixing of ideal gases – Dalton's law of partial pressure, evaluation of propertiesof ideal gases.				
Module 5: **Power Cycles**	In class	**Gas Power Cycles:** Introduction: Carnot Cycle, Air Standard Cycles: Otto Cycle, Diesel Cycle, Dual Cycle, Comparison of Otto, Diesel and Dual Cycles. **Vapour Power Cycles:** Rankine Cycle, Actual vapour cycle processes, Comparison of Rankine and Carnot Cycles, Mean temperature of heat addition, Methods of increasing thermal efficiency, Reheat and Regenerative cycle, Feed water heater, characteristics of ideal working fluid.	10	5		
	Assignment topics	Numerical questions from power cycles				

Text books:

1. P K Nag: Engineering Thermodynamics, Tata McGraw Hill
2. R K Rajput: A Text Book of Engineering Thermodynamics, Laxmi Publications, New Delhi

Reference books:

1. M W Zemansky: Heat and Thermodynamics, McGraw Hill
2. Joseph H. Kennen: Thermodynamics, John Wiley
3. Sontag, Borgnakke and Van Wylen: Fundamentals of Thermodynamics, John Wiley
4. C P Arora: Thermodynamics, Tata McGraw

Sub Code: **ME202A1** **Credit: 4 (L-3, T-1, P-0)**

MECHANICS OF SOLIDS-I

Questions to be set: 05 (All Compulsory)

Course Objective: This course offers knowledge on coplanar concurrent and non-concurrent force system, centroid and moment of inertia, stress, strain. The objective of this course is to enable the student to understand concept of stress on oblique plane, SFD/BMD, torsion in shaft. Upon completion of this course, the student should be able to:

1. Understand the concept and calculate stresses and strains on oblique plane using different methods.
2. Understand the concept of centroid and moment of inertia.
3. To provide the fundamental of torsion, SFD/BMD.

Pre-requisites: Knowledge of Engineering Mechanics, Engineering Mathematics.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	Determine the Equilibrium of System of Forces, Equilibrium of System of Forces.
CO2	Apply various methods to calculate centroid and area moment of inertia, Moment of inertia of plane sections from first principles, Theorems of moment of inertia.
CO3	To evaluate the strength of various structural elements under different types of forces such as compression, tension, shear, bending and torsion.
CO4	To plot the variation of shear force and bending moments over the beams and shaft under different types of loads.
CO5	Calculate the stresses and strains on oblique plane using different methods.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Coplanar Concurrent and Coplanar Non-Concurrent Force System**	In class	Importance of Mechanics in engineering; Types of forces, Resultant of a force system, graphical principles-parallelogram law, triangle law, polygon rule, analytical method, conditions of equilibrium, Concept of free body diagrams, Lami's theorem; Numerical problems. Moment of a force, Varignon's theorem, couple, properties of couples, resultant of non-concurrent force system, conditions of equilibrium; Numerical problems.	8	1		
	Assignment topics	Numericals				
Module 2: **Centroids and Moment of Inertia**	In class	Centroid: Concept of centre of gravity, centroid of area, centroid of line, concept of line of symmetry, location of centroid by direct integration of rectangular, triangular, semi-circular and quarter circular areas, centroid of composite areas; Numerical problems. Moment of Inertia: MI of plane figure with respect to an axis in its plane, MI of plane figure with respect to an axis perpendicular to the plane of the figure; Parallel axis theorem; Mass moment of inertia of symmetrical bodies, e.g. cylinder, sphere, cone.	12	2		
	Assignment topics	Numericals				
Module 3:	In class	Mechanical properties of materials, concept of stresses and strains, stress-strain diagrams, yield stress, ultimate	10	3		

Simple Stresses and Strains		stress, limit of proportionality, elastic limit, working stress, factor of safety, Hooke's law, Young's modulus(Modulus of elasticity), rigidity modulus, bulk modulus, Poisson's ratio, relationship among the elastic constants, bars of varying cross sections, elongation due to self-weight; Concept of mechanics of deformable solids; concept of stress developed against external force/pressure; Deformation of axially loaded members, statically determinate and indeterminate problems.				
	Assignment topics	Numerical problems.Castiglianos theorem, Maxwell's reciprocal theorem. application of Castiglianos theorem in solution of statically indeterminate problem. Numericals				
Module 4: **Shear Force and Bending Moment Diagrams, Stresses in Beams**	In class	Definition of bending moment and shear force at a section, sign convention, relationship between bending moment, shear and load intensity, shear force diagrams (SFD) and bending moment diagrams (BMD) for statically determinate beams subjected to point loads, uniformly distributed loads uniformly varying loads and couples. Loading diagram corresponding to the given SFDs. stresses in beams of various cross sections.	8	4		
	Assignment topics	Numericals				
Module 5: **Principal Stresses and Strains, Torsion**	In class	Mohr's circle for stresses on an oblique section of a body subjected to direct stresses in two mutually perpendicular directions, Mohr's circle for stresses on an oblique section of a body subjected to direct stress in one plane accompanied by a simple shear stress, Mohr's circle for stresses on an oblique section of a body subjected to direct stresses in two mutually perpendicular directions accompanied by a simple shear stress, Mohr's circle for strain. Torsion: Torsion formula for circular cross-sections, Maximum normal and shear stresses, Angle of twist, combined bending & torsion of solid & hollow shafts	10	5		
	Assignment topics	Numericals				

Textbooks:

1. S. S. Ratan - Strength of materials, Tata Mcgraw hill.
2. Beer, Johnston and Dewolf– Mechanics of materials- Tata Mcgraw hill
3. Timoshenko and Young - Elements of Strength of Materials - East west press.
4. Ramamrutham and S Narayan–Strength of Materials-Dhanpat Rai& Publications.
5. Nag and Chanda- Fundamentals of Strength of Materials, Wiley India.
6. G. H. Ryder - Strength of materials, Macmillan India

Reference Books:

1. Kamal Kumar, R. C. Ghai–Advanced Mechanics of Materials- Khanna Publishers
2. L. S. Srinath- Advanced Mechanics of Solids-TMH

Sub Code: **ME203A1** **Credit: 4 (L-3, T-01, P-0)**

MANUFACTURING PROCESS

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able to:

1. To understand the basic concept of casting, welding, and forming processes.
2. To understand the basic concept of different traditional machining processes and its applications.
3. To analyze the different machining parameters with various machining operations.
4. To understand the basic concept of different non-traditional machining processes

Pre-requisites: Knowledge of basic day to day manufacturing process, Engineering Mathematics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Explain the various types of casting, furnace, welding techniques.
CO2	Acquire knowledge about various mechanical working of metals, rolling, forging, extrusion, non-destructive testing of metals.
CO3	Analyze & demonstrate the metal cutting, chip formation, geometry of single point cutting tools, cutting fluids, tool failure.
CO4	Learn the various mechanisms of lathe machine, drilling, shapers and milling machine which they imply in workshop practice lab.
CO5	Apply the knowledge on Indexing in milling and also acquire knowledge of various grinding operations.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Casting and Welding:**	In class	Introduction to casting process Types of patterns solidification time, choke area calculation, gating ratio (choke area: runner area: gate area) and pouring time, Special casting process. welding introduction, carbon arc welding, shielded arc welding, TIG and MIG welding, submerged arc welding	8	1		
	Assignment topics	Properties, Green sand moulding, Brief description of working of electric arc furnace, Laser welding and Electron beam welding.				
Module 2: **Mechanical working of metals**	In class	Definition, classification, Hot working and cold working, recrystallization, Rolling Principles, types, methods, and applications, Drawing and its applications, Rolling numerical, Numerical associated with Drawing, Methods, and processes	8	2		
	Assignment topics	forging presses and dies, impact forging, press forging, upset forging, forge welding, power hammers – spring, pneumatic and drop type, Processes, sheet metal dies – simple, compound and combination dies				
Module 3: **Theory of metal cutting**	In class	Introduction to Tool nomenclature, geometry of single point cutting tool, cutting speed, feed, depth of cut and their selection; Merchant's circle diagram; tool wear and tool life.	8	3		
	Assignment topics	Orthogonal and oblique cutting, mechanism of chip formation, types of chips.				
Module 4: **Lathes, shaping, drilling, milling**	In class	Constructional features, turning, step turning, facing, boring, knurling, drilling, taper turning, thread cutting; simple calculations for cutting speed, feed, depth of cut and machining time, quick return mechanism for shapers, calculations. Drilling constructional features, milling operations like up milling, down milling, gang milling, slab milling, straddle milling and end milling.	6	4		

	Assignment topics	Classification, accessories and attachment, types of lathes, Classification, constructional features of shaper, Constructional features, classification of drilling, Constructional features, classification of milling machines.				
Module 5: **Indexing and grinding**	In class	Purpose of indexing, simple, compound, differential, and angular indexing with calculations. Classification, constructional features, operations, surface, cylindrical and center less grinding machines.	6	5		
	Assignment topics	Types, specification, constructional features				

Text Books:

1. P. N. Rao: Manufacturing Technology – Metal Cutting and Machine Tools; TMH,
2. P. N. Rao: Manufacturing Technology – Manufacturing technology; TMH

Reference Books:

1. R. K. Jain: Production Technology; Khanna Publishers
2. Hajra Choudhary: Elements of Workshop Technology –Vol-II; Media Promoters and Publishers

Sub Code: **ME201A4** **Credit: 1 (L-0, T-0, P-2)**

STRENGTH OF MATERIALS LAB

Course Objective: In this course the concept of various effects due to tension, compression, bending effects on material more precisely.

Pre-requisites: Basic concepts of Strength of Materials.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Demonstrate the various tests on the ductile and brittle materials.
CO2	Investigate the various effects on the materials after the tests.

Ultimate tensile strength (**UTS**): Determination of tensile strength of different materials (e.g. Aluminium and Mild steel)
Ultimate shear strength: Determination of shear strength of mild steel rod.
Compressive strength: Determination of compressive strength of mild steel rod, wooden block and brass rod.
Hardness: Hardness testing of mild steel specimen using Rockwell, Brinell's and Vickers hardness testing machine.
Impact strength: Strength testing of mild steel/Cast iron specimen using Charpy Impact Test and Izod Impact Test.
Torsional strength: Determination of modulus of rigidity of a mild steel specimen.
Fatigue strength: Determination of endurance limit of a mild steel specimen on fatigue or cyclic loading
Spring Testing: Determination of stiffness of the spring and modulus of rigidity of the spring wire

The broad area for conduct of experiments is given above. However, the specific list of experiments is as given below. Students are required to perform minimum 12 experiments during the semester in the Strength of Materials Lab.

List of Experiments:-

1. To find out the tensile strength of mild steel/aluminium specimen using Universal Testing Machine (UTM).
2. To determine the ultimate shear strength, in single shear and double shear of mild steel rod specimen
3. To determine the compressive strength of mild steel specimen under gradually increasing compressive load
4. To determine the compressive strength of wood specimen under gradually increasing compressive load.
5. To determine the compressive strength of brass specimen under gradually increasing compressive load.
6. To determine the indent's hardness of mild steel specimen using Rockwell Hardness Testing method.
7. To determine the indent's hardness of mild steel specimen using Brinell's and Vickers hardness testing method
8. To determine the impact resistance of mild steel/cast iron specimen using Charpy test
9. To determine the impact resistance of mild steel/cast iron specimen using Izod impact testing
10. To carry out torsional test on mild steel specimen and find its modulus of rigidity
11. To determine the endurance limit of the given specimen (mild steel) under fatigue or cyclic loading.
12. To determine the stiffness of the spring and modulus of rigidity of the spring wire.

Reference books:

1. Timoshenko & Young - Elements of Strength of Materials - East west press.

Sub Code: **ME202A4** **Credit: 1 (L-0, T-0, P-2)**

CAE LAB

Course Objective:

1. Appreciate the concepts of front view, top view and side views.
2. To gain a good working understanding of Geometric Dimensioning and Tolerancing.
3. To gain an understanding and appreciation of modern industrial design.
4. To understand modern CAD/CAM operations.
5. To gain a working knowledge of concurrent engineering.
6. To be able to use a modern CAM system.
7. To understand CNC machine tool capabilities.

Pre-requisites: Engineering Graphics, Machine Drawing, Basic Knowledge of CAD/CAM operating Languages.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Students will be able to solve the problems related to various views of bulky designs.
CO2	Students will be able to design 3d models by using drafting softwares.
CO3	Be able to design parts in a modern parametric CAD system for manufacture on a rapid prototyping machine and/or a CNC machining system.
CO4	Be able to use geometric dimensioning and tolerancing based on the ASME standard in design and to generate proper engineering drawings.

CADIAN software

Basic CADIAN commands, Co-ordinate, draw commands, editing, dimensioning Technical Drawings using CADIAN

Orthographic Projections, sectional views, isometric projections, 3D drawings, solid modeling

CREO parametric:

Overview on setting working directory and saving the work, Various tolls, orthographic projection, part drawing, 3-D modeling, assembly.

The broad areas for conduct of experiments are enlisted above. However, the specific lists of experiments are as follows. Students are required to perform minimum 12 experiments during the Lab in a semester.

List of Experiments:-

1. To draw orthographic projection of isometric object 1& 2 using basic drawing tools.
2. To draw isometric projection of orthographic object 1 & 2 using drawing tools.
3. To draw solids 1 & 2 using 3D drawing tools.
4. Modelling of isometric block-1 and 2- Modelling by using tools like extrude, pocket, etc.
5. Modelling of isometric jug/ container-Modelling by using tools like revolve, shell, etc.
6. Modelling of piston along with piston pin and circlips-Individual modelling and assembly of each by considering suitable constraints.
7. Modelling of universal joint-Individual modelling and assembly of each by considering suitable constraints.
8. Wireframe modelling of cigar-pipe-Wireframe and surface modelling by using tools like variable/ multi-section, etc. and addition of thickness.
9. Surface modelling of water bottle-Surface modelling by using tools like variable/ multi-section, diabolo/ impression of different figs., etc. and addition of thickness.
10. Assembly of part design-1. Assembly of more than two part design using different assembly tools.
11. Assembly of part design-2. Assembly of more than two part design using different assembly tools.

12. Conversion of 3D models into 2D drawings and universal file convertors-Selected models to be converted into 2D drawing for manufacturing along with are converted for CNC machining by using to .dxf, .iges and .step.

Text Books:

1. N. D. Bhatt: Engineering Drawing, Charotar Publishing House Pvt.Ltd.

Reference books:

1. Paul J. Drake Jr.: Dimensionig and tolerancing handbook, McGraw-Hill Education.
2. T. Jeyapoovan: Engineering Drawing and Graphics using Autocad, Vikas Publishing House.
3. Zimmer & Groover : CAD/CAM Computer Aided Design and Manufacture, Prentice Hall of India Pvt/ Ltd., New Delhi.
4. Ibrahim Zeid: CAD/CAM, Theory & Practice, TMH.

Sub Code: **MA204A1** **Credit: 4 (L-3, T-1, P-0)**

ENGINEERING MATHEMATICS IV

Questions to be set: 05 (All Compulsory)

Course Objective:
In higher studies, analytical solution of various types of algebraic, transcendental and ordinary differential equations are not always possible or not so easy. Numerical methods are helpful to solve. Polynomial interpolation plays an important role for designing applications related to mechanical engineering.

Pre-requisites: MA10101A, MA10102A, MA101115A

Course Outcomes (CO): This will equip mechanical engineers with the analytical tools required for building robust systems.

CO	STATEMENT
CO1	Apply the concept of interpolation in mechanical engineering problems.
CO2	Apply the concept of numerical differentiation and integration in mechanical engineering systems and devices.
CO3	Understand the methods of solving algebraic and transcendental equations and their applications in Fluid Mechanics, Dynamics of Machine.
CO4	Apply the concept of system of equations and their application in mechanical engineering problems.
CO5	Apply the concept of numerical solution of Initial value problem and their applications in Fluid Mechanics.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Interpolation**	In class	Interpolation and application: finite difference, central and divided differences, Newton - Gregory and Lagrange's interpolation formulae.	5	1		
	Assignment topics	Inverse interpolation.		1		
Module 2: **Numerical differentiation and integration**	In class	Numerical differentiation. Numerical integration: Trapezoidal rule, Simpson's one third rule.	5	2		
	Assignment topics	Simpson's three eight rule.		2		
Module 3: **Numerical solution of algebraic and transcendental equations**	In class	Numerical solution of algebraic and transcendental equations using method of ordinary iteration. Regula Falsi and Newton Rapson's method. Simple examples, conditions for rate of convergence. Solution of nonlinear equation by Newton Rapson's method. Simple examples.	8	3		
	Assignment topics	Multiple roots of polynomial equations.		3		
Module 4: **Solution of systems of linear equations**	In class	Solution of systems of linear equation: Direct Methods, Iterative Methods: Jacobi, Gauss-Seidal. Solution of tridiagonal systems. Eigen values and eigen vectors of matrices and elementary properties, computation of largest eigen value by power method.	8	4		
	Assignment topics	Eigen values and eigen vectors of matrices.		4		
Module 5: **Numerical solution of**	In class	Numerical solution of initial value problems in ordinary differential equations by Taylor series method, Picard's method, Euler's method, Modified Euler's method, RungeKutta second and fourth order	10	5		

initial value problems		method, Predictor and Corrector Method: - Millne's, Adam Bashforth.				
	Assignment topics	Predictor and Corrector Method: - Adam Moulton method.		5		

Text books:

1. S.S. Sastry : Introductory methods of numerical analysis, PHI .
2. Conte S, DeBoor, Elementary Numerical Analysis, An Algorithmic Approach, McGraw Hill.
3. J. Scarborough: Numerical Mathematical Analysis, Oxford & IBH Publishing.

Reference books:

1. M.K. Jain and S.R.K. Iyengar and R.K. Jain: Numerical Techniques for scientific and engineering computations. New Age International.
2. V Rajaraman: Computer Oriented Numerical Methods, PHI.

Sub Code: **ME204A1** **Credit: 4 (L-3, T-1, P-0)**

MECHANICS OF SOLIDS-II

Questions to be set: 05 (All Compulsory)

Course Objective: This course offers knowledge on strain energy. The objective of this course is to enable the student to understand concept of deflection in beams, column and struts, thin and thick cylinder etc. Upon completion of this course, the student should be able to:

1. Understand the concept of strain energy.
2. Understand the concept of columns and struts.
3. To provide the fundamental of deflection in beams, thin and thick cylinders.

Pre-requisites: Knowledge of Engineering Mathematics, Strength of Materials.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	To find the strain energy in different types of stress systems.
CO2	To find the deflection of beams under different types of loading.
CO3	To understand the basic concept of analysis and design of structural elements such as columns and struts.
CO4	To understand the stresses present in thin, thick and compound cylinders.
CO5	To understand the stresses present in curved beam and rotating discs.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Elastic Strain Energy and Energy Methods**	In class	Introduction, Resilience, Proof resilience, modulus of resilience, Types of loading: gradually applied, suddenly applied, impact, Elastic strain energy in a uniaxial stress system, Elastic strain energy in shear, Strain energy in 3D stress system, strain energy in axially loaded bar, strain energy in bending, strain energy for shaft in torsion. Castiglianos theorem, Maxwell's reciprocal theorem. application of Castiglianos theorem in solution of statically indeterminate problem	8	1		
	Assignment topics	Numericals				
Module 2: **Deflection of Beams**	In class	Curvature of bending beams, relation between slope, deflection and radius of curvature, method for slope and deflection at a section: Double integration method, Macualay‟s method, Area-moment method.	10	2		
	Assignment topics	Numericals				
Module 3: **Columns and Strut, Springs**	In class	Theory of columns; eccentric loading of short strut; column buckling: Euler load for columns with pinned ends and other end restraints; Euler‟s curve; empirical column formulae –(i) straight line, (ii) parabolic and (iii) Rankine Gordon. Springs: Deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial	10	3		

		load and twisting moment acting simultaneously both for open and closed coiled springs.				
	Assignment topics	Numerical problems.				
Module 4: **Thin and Thick Cylinders**	In class	Introduction, difference between thin walled and thick walled pressure vessels, thin walled spheres and cylinders, hoop and axial stresses and strain, volumetric strain. Stresses in a thick cylindrical shell- Lame's equations, Compound Cylinders- Stresses in compound thick cylinders, initial difference in radii at the junction of a compound cylinder for shrinkage.	12	4		
	Assignment topics	Numericals				
Module 5: **Curved Beams and Rotating Discs**	In class	Bars with large initial curvature, Link radius for standard section: Rectangular, Triangular, Trapezoidal, Circular Crane hooks, Rings, Chain links Rotating discs: Stress equilibrium equations in polar co-ordinates, Stresses in rotating discs, Solid disc, and with a central hole, rotating disc of variable thickness, rotating of uniform strength.	8	5		
	Assignment topics	Numericals				

Textbooks:

1. S. S. Ratan - Strength of materials, Tata Mcgraw hill.
2. Beer, Johnston and Dewolf– Mechanics of materials- Tata Mcgraw hill
3. Timoshenko and Young - Elements of Strength of Materials - East west press.
4. Ramamrutham and S Narayan–Strength of Materials-Dhanpat Rai& Publications.
5. Nag and Chanda- Fundamentals of Strength of Materials, Wiley India.
6. G. H. Ryder - Strength of materials, Macmillan India

Reference Books:

1. Kamal Kumar, R. C. Ghai–Advanced Mechanics of Materials- Khanna Publishers
2. L. S. Srinath- Advanced Mechanics of Solids-TMH

Sub Code: **ME205A1** **Credit: 4 (L-3, T-1, P-0)**

THEORY OF MACHINES-I

Questions to be set: 05 (All Compulsory)

Course Objective: This course emphasizes on the concept of velocity and acceleration analysis of mechanism, Kinematics of lower and higher pairs, concept of Inversions of mechanism, concept of various power drives.

Pre-requisites: Basics of mechanical engineering, Applied mechanics, Basic concepts of statics and dynamics.

Course Outcomes (CO): On successful completion of the course:

CO	STATEMENT
CO1	Students will understand the basic of the kinematics of mechanism, types of mechanism and their inversions.
CO2	Students will able to analyze the velocity and acceleration analysis by different methods.
CO3	Students will demonstrate the ability to analyze the gear and gear trains.
CO4	Students will demonstrate the ability to analyze the belts drives.
CO5	Students will understand the concept of friction in various mechanical elements and will able to design various mechanism after studying this subject.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction and definitions**:	In class	Link, element, kinematic pairs – their classification and degrees of freedom, kinematic chain, mechanism, inversion and machine.	4	1		
	Assignment topics	Numerical				
Module 2: **Kinematic chains, inversions and mechanisms**	In class	Four bar chain, mobility of a mechanism – Grashof's law for movability of a Four bar mechanism, Quick return motion mechanisms, Hooke's joint, Ackermann and Davis steering gear mechanisms,	6	1		
	Assignment topics	Pantograph, Some Other Mechanisms				
Module 3: **Velocity and acceleration analysis**	In class	Determination of velocity and acceleration in mechanisms by relative velocity and relative acceleration methods; relative velocity and relative acceleration of particles on a common link and coincident particles on separate links – Coriolis component of acceleration.	8	2		
	Assignment topics	**Instantaneous centre of rotation**: Definitions, Aronhold–Kennedy's theorem of three centers and its application to locate instantaneous centers; Determination of velocity by instantaneous centre method.				
Module 4: **Toothed gearing and Gear trains**	In class	Classification of gears, nomenclature for straight spur gears, fundamental law of gearing, conjugate teeth, involute and cycloidal tooth profiles, path of contact and arc of contact, interference in involute gears, methods of avoiding interference – undercutting, Simple gear trains, compound gear trains for large speed reductions – gear box of an automobile; epicyclic gear trains, alternate methods of determining velocity ratio of epicyclic gear trains, tooth loads and torque	10	3		

		calculations in epicyclic gear trains. Differential mechanism of an automobile.				
	Assignment topics	Numerical				
Module 5: **Belt drive and Friction**	In class	Flat and V belts, limiting ratio of tensions, effective tension and power transmitted, centrifugal tension in a belt, effect of centrifugal tension on power transmitted. Thrust bearings, single and multi-plate clutches, cone clutches, centrifugal clutches.	8	4,5		
	Assignment topics	Numerical				

Text Books:

1. A. Ghosh and A.K. Mallik: Theory of Mechanisms and Machines, East West Press
2. Jagdish Lal: Theory of Mechanisms and Machines, Metropolitan Book Co Delhi
3. A.G. Ambekar: Mechanism and Machine Theory, Jain Brothers, New Delhi
4. V.P.Singh: Theory of Machines, Dhanpat rai & Co

Reference Books:

1. T. Bevan: Theory of Machines, CBS Publishers
2. Mabie and Reinholt: Mechanisms and Dynamics of Machinery, John Wiley
3. S.S.Rattan: Theory of Machines, Tata McGraw Hill

Sub Code: **ME203A4** **Credit: 1 (L-0, T-0, P-2)**

COMPUTATIONAL LAB

Course Objective:
1. To know the basic concepts problem solving.
2. To understand the basic concepts of C.
3. To develop the programming skills of students in C.

Pre-requisites: Engineering Mathematics IV, Basic programming language.

Course Outcomes (CO): On Successful Completion of the course:

CO	STATEMENT
CO1	Students will become familiar with fundamentals of Python programming and to apply to solve various science and technology related problems.
CO2	Students will become equipped with the knowledge and skills necessary for entry-level placement in Mechanical, Mechatronics and Electrical Engineering as well as IT companies.

Interpolation: Newtonian polynomial interpolation formulae (Forward and Backward interpolation), Newton's divided difference, Lagrange's interpolation formula,
Numerical Integration: Trapezoidal rule, Simpson's one third and three eighth rule.
Solution of Transcendental Equation: Numerical solution of algebraic and transcendental equations using method of ordinary iteration. Regula Falsi and Newton Rapson's method.
Solution of systems of linear equation: i) Direct Method: Gauss Elimination and LU decomposition method, Iterative Method: Jacobi, Gauss –Seidal method. Method for Matrix Inversion.
Solution of Differential Equation: Numerical solution of initial value problems in ordinary differential equations by Euler's method, Runge Kutta fourth order method. Finite difference method for the solution of boundary value problems in linear ordinary differential equations using central differences.

The above are the broad area of conduction of experiments. However the specific list of experiments are the following. Students are required to perform minimum 12 experiments during the Lab in a semester.

List of Experiments:-
1. To write a Python program on Bisection Method.
2. To write a Python program on Regula Falsi Method.
3. To write a Python program on Newton Rapson's Method.
4. To write a Python program on Trapezoidal rule Method.
5. To write a Python program on Simpson's one third Method.
6. To write a Python program on Simpson's three eighth Method.
7. To write a Python program on Gauss Elimination Method.
8. To write a Python program on Iterative : Jacobi Method.
9. To write a Python program on Iterative: Gauss –Seidal method Method.
10. To write a Python program on Forward interpolation Method.
11. To write a Python program on Backward interpolation Method.
12. To write a Python program on Runge Kutta fourth order Method.

TextBooks

1. S. Arumugam, A. Thangapandi Issac, A. Somasundaram: Namerical Methods, Scitech.
2. E. Balagurusamy: NUMERICAL METHODS, Mcgraw Higher Ed.
3. W. Chun: Core python programming (Vol. 1). Prentice Hall Professional, 2001.

Reference Books

1. M. Summerfield. Programming in Python 3: a complete introduction to the Python language. Addison-Wesley Professional, 2010

Sub Code: **ME204A4** **Credit: 1 (L-0, T-0, P-2)**

MANUFACTURING AND METROLOGY LAB

Course Objective:

1. To familiarize the students with the various types of manufacturing and measuring instruments.
2. To deals with the modern manufacturing technique to fulfill industrial demand.
3. The students will also understand the standardization of products.

Pre-requisites: Manufacturing process, Basic of measurement, Material Science.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	To understand the operation of modern manufacturing machine tools dealing with high accuracy and precision that fulfills the high end technical demand.
CO2	To understand the important of precision, accuracy, and reliability.
CO3	To gain practical experience in using measuring tools, and where and how to use them.
CO4	To understand the difficulties in reliably measuring to high precision.
CO5	To understand the sources of errors, and how to avoid or compensate for them.

Grinding: Fundamentals of grinding operation, Applications of different bonded grinding wheel, G-ratio, grinding wheel specifications and surface grinding operation.
CNC Turning: Handling of a CNC machine, idea about G-code, M-code
Measurement of Cutting force: Measurement of cutting forces (P_x, P_y, P_z) associated during a turning operation.
EDM: Different parts of EDM machine, requirement of dielectric fluid and die-sinking operation.
LBM: Different parts of LBM, and demonstration on Laser Beam Machining.
Welding: TIG, MIG
Linear Measurement: Measurement using various kind of vernier caliper, calibration of various types of vernier caliper using slip gauges, measurement using micrometer.
Angular Measurement: Angular measurement using using Bevel Protractor and Sine Bar.
Limit Fit and Tolerances: Inspection using Plain Ring Gauges, Snap Gauges.
Calibration of Instruments: Calibration of Vernier caliper using slip gauges.
Slip Gauges: Grades, Wringing, Selection of Slip Gauges for the required dimension.
Flatness Measurement: Measurement of Flatness of Surface plate**.**
Diametral Measurement: Measurement of bore diameter using two sphere methods.
Screw thread Metrology: Measurement of thread parameter using profile projector.
Gears Measurement: Backlash measurement, Gear Tooth thickness Measurement, Checking involute shape of Gear, Base pitch measuring instrument.

The broad areas for conduct of experiments are above listed. However, the specific lists of experiments are as follows. Students are required to perform minimum 12 experiments during the semester in lab.

List of Experiments:-

1. Measurement of cutting forces (Pz and Px or Py) in turning with different feeds and cutting velocities using 3D force dynamometer and evaluation of shear angle.
2. To fabricate butt joint by TIG/MIG welding.
3. To perform grinding operations on a given job using surface grinding machine.
4. To perform turning operation as per given specification using CNC Lathe.
5. To study the characteristic features of LBM processes.
6. To evaluate the EDM performance characteristics by changing the input parameters.
7. To perform shaping/ slotting operation as per given dimensions.
8. To perform end milling operation to achieve given dimensions on a job.
9. Measurement and Calibration of Vernier Caliper using Slip gauge.
10. Measurement and Calibration of Vernier Height gauge.

11. Measurement and Calibration of Vernier Depth gauge
12. Measurement by using micrometer.
13. Angular measurement by using Bevel Protractor.
14. Angular measurement by using Sine Bar.
15. Measurement of thread parameter using profile projector.
16. Measurement of Flatness of Surface plate.
17. Measurement of Gear Elements.
18. Measurement by using slip gauge.
19. Measurement of bore diameter by two spheres method.
20. Inspection using ring limit gauges.
21. Checking the squareness of try square using slip gauge.

Reference books:

1. W.A.J. Chapman: Workshop Technology, Edward Arnold
2. S. K. Hajra Choudhury: Elements of Workshop Technology, Indian Book Distributing Co.
3. B.S. Raghuvanshi: A Course in Workshop Technology, Dhanpat Rai & Co. Ltd.
4. K.J. Hume: Engineering Metrology, Macdonald
5. K. W. B Sharp: Practical Engineering Metrology, Pitman
6. M. R. Taher: Metrology of Measuring Instruments, Ram Narayan and Bhani Prasad

Sub Code: **ME301A1** **Credit: 4 (L-3, T-1, P-0)**

THERMAL ENGINEERING-II

Questions to be set: 05 (All Compulsory)

Course Objective: This course is designed for providing comprehensive understanding and thermodynamic analysis of boilers used in power generation, gas turbine power plants, compressors and jet propulsion systems.

Pre-requisites: Basics knowledge of heat, work and energy, laws of motions., various gas laws. knowledge of element of mechanical engineering and basic thermodynamics is required.

Course Outcomes (CO): On Successful Completion of the course students will be:

CO	STATEMENT
CO1	Able to identify different types of boilers in industries and realize their usage according to the demand.
CO2	Able to conduct performance investigation of steam boilers.
CO3	Able to investigate the performance of gas power plants.
CO4	Able to apply the concept of thermodynamic process while investigating the performance of gas compressor.
CO5	Able to apply the concepts of compressible fluid flow in jet propulsion systems

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Steam Generators**	In class	Introduction, Classification of boilers, Boiler details, Fire Tube boilers, Water tube boilers, High Pressure boilers, Essentials requirements of a good boiler.	6	1		
	Assignment topics	Construction and working of any one boiler.				
Module 2: **Steam Generator Performance**	In class	**Draught:** Definition and classification of draught, Natural draught Chimney, Chimney height and diameter, Condition for maximum discharge through chimney, Efficiency of a chimney, Draught losses, Artificial draught – Forced draught, Induced draught, and Balanced draught. **Performance of Steam Generators:** Evaporation capacity, Equivalent evaporation, Factor of evaporation, Boiler efficiency, Heat losses in a boiler plant, Boiler Trial and Heat Balance.	8	2		
	Assignment topics	Numerical questions from draught and boiler performance				
Module 3: **Gas Turbine**	In class	Cycle Arrangements- Introduction, Open Cycle Arrangements, Closed Cycle, Assumptions in ideal cycle analysis, Simple Gas Turbine Cycle, Heat Exchanger cycle, Reheat Cycle, Intercooled cycle, intercooled cycle with heat exchanger and reheat. **Practical Cycles and their analysis:** Assumptions, Stagnation properties, Compressor and turbine efficiency, Pressure Loss, Heat Exchanger effectiveness, Variation of Sp. Heat, Mechanical Losses, Incomplete combustion Loss, Cycle efficiency, Polytropic efficiency, Performance of actual cycle.	8	3		
	Assignment topics	Numerical questions from gas turbine power plant and practical cycles				

Module 4: **Reciprocating Air Compressor**	In class	Single Stage Compressor, Work done by Air compressor with and without clearance, Volumetric efficiency, Isothermal efficiency, Methods adopted for increasing isothermal efficiency, Multistage compression, Condition for minimum work, Cylinder dimensions of multistage compression, Intercooler.	7	4		
	Assignment topics	Numerical questions from compressor				
Module 5: **Jet Propulsion**	In class	Criteria of performance, Ram and propelling nozzle efficiencies, Turbo jet engine – Thrust, Thrust power, Propulsive power, Propulsive efficiency, Critical pressure ratio	7	5		
	Assignment topics	Numerical questions from jet propulsion				

Text books:

1. C. P. Kothandaraman, A. V. Domkunwar: A course in Thermal Engineering;Dhanpat Rai & Sons
2. P. L. Ballaney: Thermal Engg. Khanna Publishers

Reference books:

1. V. Ganeshan: I.C. Engines, TMH publisher
2. B. K. Sarkar: Thermal Engineering: TMH publisher

Sub Code: **ME302A1** **Credit: 4 (L-3, T-1, P-0)**

MACHINE DESIGN-I

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To provide the ample knowledge of fundamentals of design criterion.
2. Understand the design of various mechanical coupling for power transmission.
3. Understand the design of various types of mechanical joints.

Pre-requisites: Fundamental of SOM, Material science.

Course Outcomes (CO): On successful completion of the course student will be able to:

CO	STATEMENT
CO1	Apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.
CO2	Determine forces on transmission shaft and keys and design of transmission shaft and keys.
CO3	Demonstrate the ability to analyze the design of couplings. Students will demonstrate the ability to analyze the design of brakes.
CO4	Determine the forces in welds and riveted joints and formulate design solution for size of weld and size of rivet.
CO5	Determine forces on power screw and bolted joints and formulate design solution for size of power screw and size of bolt. Use of Design Data Handbook for designing of various mechanical parts.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Fundamentals**	In class	Working stresses, Stress-strain diagram for ductile and brittle materials. Factor of Safety. Ductile materials subjected to steady stresses. Members subjected to biaxial loading, principal stresses, stress concentration, theoretical stress concentration factor, and theories of failure. Endurance limit, variables affecting fatigue strength, combined stress concentration factor, members subjected to combined steady and alternating loads.	8	1		
	Assignment topics	Numerical				
Module 2: **Keys and Couplings**	In class	Types of keys, stress in keys,design of square, rectangular and taper keys. Flange coupling bushed pin type flexible coupling	5	2,3		
	Assignment topics	Knuckle joint, cotter joint				
Module 3: **Shafting**	In class	Torsion of circular shafts, solid and hollow shaft. ASME and ISI codes equations for design of transmission shafts. Mises Hencky theory for transmission shafting, stress concentration. Design of shafts subjected to combined loads.	5	2		
	Assignment topics	Numerical				
Module 4: **Riveted joints and Welded joints**	In class	Types, modes of failure, strength and efficiency of riveted joints, pitch of rivets, design stresses, structural joints of lap and butt types, boiler joints. Strength of welds,	8	4		

	Assignment topics	Rivets subjected to eccentric loading, eccentric loaded welded joints, welded pressure vessels, some practical applications.				
Module 5: **Threaded fasteners, power screws and Brakes**	In class	Stresses in bolts, effect of initial tension, eccentric loading, power screws, stresses in power screws, force and torque required to lift a load in power screw jack. Energy equations block brake with short shoe, internal expanding brake, band brakes	10	3,5		
	Assignment topics	Numerical				

Text Books:

1. K. Mahadevan and K. Balaveera reddy: Design Data Handbook (SI Units), KREC, Surathkal
2. Spotts: Design of Machine Elements, Prentice Hall (India)
3. V. B. Bhandari: Introduction to Machine Design, TMH
4. P. C. Sharma and D. K. Agarwal: Machine Design, S. K. Kataria & Sons

Reference Books:

1. J. Shigley: Mechanical Engineering Design, McGraw Hill
2. Martin J. Siegel, Vladmir L. Maleev and J.B. Hartman: Mechanical Design, International Textbook Co.
3. Sadhu Singh: Machine Design, Khanna Publishers.
4. Ghosh: Practical Machine Design, S. Bhattacharya Co.

Sub Code: **ME303A1** **Credit: 4 (L-3, T-1, P-0)**

THEORY OF MACHINE-II

Questions to be set: 05 (All Compulsory)

Course Objective:

1. Know different machine elements and mechanisms.
2. Understand kinematics and dynamics of different machines and mechanisms.
3. Appreciate concept of balancing and vibration.
4. Develop ability to come up with innovative ideas.

Pre-requisites: Basic understanding of mechanics and theory of machines.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Design cam profile for given follower motions and to choose best suitable cam and follower arrangement for different requirements.
CO2	Applying the concept of inertia forces in reciprocating parts, understand the importance of turning-moment diagrams, and analyze the working of flywheel and governor.
CO3	Analyze the working of governors
CO4	Analyze the gyroscopic couple or effect for stabilization of Ship, Aero plane, and Four-wheeler vehicles.
CO5	Understand the importance and methods of balancing in rotating and reciprocating parts.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Cams**	In class	Classification of cams and followers, Terminology for radial cams, Types of follower motion –displacement, velocity and acceleration diagrams, Synthesis of profiles of radial cams for radially translating and offset translating follower, numerical	6	1		
	Assignment topics	Problems				
Module 2: **Dynamics of direct acting engine mechanism**	In class	Displacement, velocity and acceleration of piston, D'Alemberts principle- inertia force and inertia torque, piston effort and crank effort, inertia of connecting rod, Turning moment diagrams, fluctuation of speed and energy, flywheels.	6	2		
	Assignment topics	flywheels for punching press and design of rim type flywheel, and Problems, Effort and power of governors, and problems				
Module 3: **Governors**	In class	Governors: Introduction, Types of governors, Watt, Porter, Hartnell and Hartung governors, Characteristics of centrifugal governors- controlling force, stability, sensitiveness isochronism, capacity, and coefficient of insensitiveness	10	3		
	Assignment topics	Problems				
Module 4: **Gyroscopic effects**	In class	Processional motion and angular acceleration, Gyroscopic couple, some typical cases illustrating gyroscopic action –effect on naval ship, stability of two wheel and four-wheel vehicles.	6	4		
	Assignment topics	Problems on gyroscopic effect on airplane, naval ship, four wheeler and two wheeler				

Module 5: **Balancing of rotating masses and reciprocating masses**	In class	Static and dynamic balancing, two plane balancing, balancing of several masses rotating in the same plane, balancing of several masses rotating in different planes Identification of inertia forces for reciprocating masses in engine mechanisms, Partial primary balancing of single cylinder engines and locomotives, Balancing of multi cylinder engines	10	5		
	Assignment topics	Problems on balancing of rotating masses, V-twin engines and radial engines-direct and reverse crank methods				

Text Books:

1. Ghosh and A.K. Mallik, Theory of Mechanisms and Machines, East West Press
2. S. S. Rattan, Theory of Machines, Tata McGraw Hill

Reference books:

1. T. Bevan, Theory of Machines, CBS Publishers
2. J.E.Shigley, Theory of Machines and Mechanisms-Tata McGraw Hill

Sub Code: **ME304A1** **Credit: 4 (L-3, T-1, P-0)**

FLUID MECHANICS AND HYDRAULIC MACHINES

Questions to be set: 05 (All Compulsory)

Course Objective: This course offers basic knowledge on fluid statics, dynamics, and hydraulic machines. The objective of this course is to enable the student to understand laws of fluid mechanics and evaluate pressure, velocity and acceleration fields for various fluid flows and performance parameters for hydraulic machinery. Upon completion of this course, the student should be able to:

1. Solve problems involving fluid properties and shear forces resulting from Newtonian fluids.
2. Calculate the magnitude and location of hydrostatic forces on flat plates and curved surfaces immersed in a static fluid.
3. Analyze fluid systems using the integral form of the continuity, momentum, impulse momentum, and energy equation.
4. Measure velocity and fluid flow rates using flow measuring devices
5. Distinguish laminar and turbulent flows through pipes.

Pre-requisites: Knowledge of Engineering Mechanics, Engineering Mathematics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Identify importance of various fluid properties at rest and in transit.
CO2	Derive and apply general governing equations for various fluid flows
CO3	Understand the concept of boundary layer theory and flow separation.
CO4	Plot velocity and pressure profiles for any given fluid flow.
CO5	Evaluate the performance characteristics of hydraulic turbines and pumps

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Fluid Statics**	In class	**Fluid Statics** 1.1. Definitions and units of fluid pressure, pressure intensity and pressure head 1.2. Concept of atmospheric pressure, gauge pressure, vacuum pressure, and absolute pressure 1.3. Pressure measuring instruments Manometers: Simple and differential Bourden tube pressure gauge (Simple Numerical) 1.4. Buoyant force, center of buoyancy, metacenter. 1.5. Stability and Equilibrium of floating and submerged bodies.	5	1		
	Assignment topics	Definition of hydrostatic pressure, Total pressure, and Centre of pressure on immersed bodies (Simple Numerical), Archimedes' principle, Concept of floatation				
Module 2: **Fluid Kinematics and Dynamics**	In class	**Fluid Kinematics & Dynamics** 2.1. Types of fluid flow and types of flow lines 2.2. continuity equation (one and two dimensional), 2.3. kinematics of fluid element, rotational flow, irrotational flow, velocity potential and stream function; circulation and vorticity 2.4. Bernoulli's theorem (Statement and proof) Applications and limitations of Bernoulli's theorem (Venturi meter, pitot tube) (Simple Numerical) 2.5. Definition of pipe, laws of fluid friction	12	2		

		2.6. Head loss due to friction: Darcy's and Chezy's formula)				
	Assignment topics	Discharge over notches and weirs, Definition of orifices, Orifice coefficients (Cc, Cv, Cd and relation among them), Hydraulic gradient and total gradient line				
Module 3: **Boundary layer theory, Compressible fluid flow, Viscous and Turbulent flow**	In class	**Boundary layer theory** 3.1. Laminar boundary layer, turbulent boundary layer, laminar sub-layer, boundary layer thickness, momentum thickness, energy thickness & separation of boundary layer (Simple problems). **Compressible fluid flow** 3.2. Thermodynamic concepts, equations for isothermal and adiabatic flow, basic equations for compressible flow – continuity equation, Bernoulli's equation and momentum equation, expression for velocity of sound, Mach number **Viscous & Turbulent flow** 3.3. Flow of viscous fluid through circular pipe, Reynold's Experiment, Frictional losses in pipe flow, Shear stress in turbulent flow	11	3		
	Assignment topics	Methods of preventing the separation of boundary layer, Drag force on a flat plate due to boundary layer Flow of viscous fluid between two parallel plates				
Module 4: **Dimensional Analysis and Impact of Jet**	In class	**Dimensional & Model analysis** 4.1. Buckingham Π- theorem (Numerical) 4.2. Dimensionless number, Model laws, Model testing for partially submerged bodies. **Impact of Jet** 4.3. Impact of jet on fixed and moving vertical flat plates, derivation of work done on series of vanes and condition for maximum efficiency. 4.4. Impact of jet on moving curved vanes, illustration using velocity triangles, derivation of work done, efficiency (Simple Numerical)	10	4		
	Assignment topics	Types of Draft tube, Draft tube theory, Derivation and significance of Specific speed, Unit quantities, characteristics curves of Hydraulic Turbines.				
Module 5: **Turbine and Pumps**	In class	**Turbine & Pumps** 5.1. Layout and features of hydroelectric power plant 5.2. Definition and classification of hydraulic turbines 5.3. Construction and working principle of Impulse turbine (Pelton wheel), Velocity triangle of a single bucket, work done and efficiency in Pelton wheel (Numerical Problems) 5.4. Definition and classification of pumps 5.5. Reciprocating Pumps, Construction and working principle of single acting and double acting reciprocating pumps 5.6. Concept of slip and negative slip	10	5		
	Assignment topics	Hydraulic press, Accumulator, Intensifier, Ram, Torque convertor				

Text Books:

1. P. N. Modi and Seth, “Fluid Mechanics and Hydraulic Machines”, 15th edition, Standard Book House, 2002.
2. Bansal R.K., “Fluid Mechanics and Hydraulic Machines”, 5th edition, Laxmi Publications (P) Ltd., New Delhi, 1995.
3. S. k. Some and G. Biswas: Introduction to Fluid mechanics and Machinery, Tata McGraw Hill.
4. A. K. Jain: Fluid Mechanics: Including Hydraulic Machines, Khanna Publishers.

Reference Books:

1. Frank. M. White, “Fluid Mechanics”, 7th edition, McGraw Hill, 2011.
2. Fox and Mcdonald’s, “Introduction to Fluid Mechanics”, 8th edition, John Wiley, and Sons 2015.
3. S.M. Yahya: Fundamentals of Compressible Flow, Wiley Eastern
4. Jagdish Lal: Fluid mechanics, Metropolitan Book Co.

Sub Code: **ME301A4** **Credit: 1 (L-0, T-0, P-2)**

THERMAL ENGINEERING LAB

Course Objective: To understand the actual operation of IC engines and evaluation of their performance. This course also deals with the operation and performance analysis of air compressor, blower, fan, air-conditioning and refrigeration equipments. Demonstration of boiler and gas turbine parts.

Pre-requisites: Basics knowledge of thermodynamics, interaction of energy, various gas laws. And knowledge of applied thermodynamics.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Able to analyze the performance of IC engines and to identify methods for improving thermodynamic performance.
CO2	Able to analyze the performance of Air compressor, Blower and Fan which are generally used in all types of industries.
CO3	Able to analyze the performance of Air conditioning and refrigeration cycles and to identify methods for improving thermodynamic performance.

IC Engine: Study of C.I and S.I engine.Performance analysis of 2-stroke/4-stroke CI and SI engine.
Boiler: Demonstration of various kind of water tube and fire tube boiler.
Gas Turbine: Operation of gas turbine.
Reciprocating Air Compressor: Performance testing of two stage Reciprocating Air Compressor. Volumetric efficiency, Isothermal efficiency, Intercooler, Actual P-V diagrams for single-stage and two stage compressors, Power and efficiencies of a compressor**.**
Refrigeration: Mathematical analysis of vapour compression refrigeration. Performance of refrigerator, C.O.P. and Rating of refrigeration machine, volumetric efficiency.
Air Conditioning: Study of simple Air conditioning system. Performance testing of an air conditioner.
Air Blower/Fan: Working of centrifugal blower and axial fan.

The broad areas for conduct of experiments are given above. However, the specific list of experiments is as given below. Students are required to perform minimum 12 experiments during the semester in the Lab.

List of Experiments:-

1. Performance testing of a single cylinder four stroke diesel engine.
2. Performance testing of a multi cylinder four stroke petrol engine.
3. Performance testing of a multi fuel variable compression 4-stroke engine with petrol.
4. Performance testing of a multi fuel variable compression 4-stroke engine with diesel.
5. Performance testing of two stage reciprocating air compressor.
6. Performance testing of an air conditioner trainer.
7. Performance testing of a refrigeration trainer.
8. Performance testing of axial fan.
9. Performance testing of centrifugal blower with forward impeller.
10. Performance testing of centrifugal blower with backward impeller.
11. Performance testing of centrifugal blower with radial impeller.
12. Study of various kinds of boilers.
13. Study of Gas turbine.
14. Study of 2-stage/4-Stage petrol and diesel engine.

Reference books:

1. P K Nag:Engineering Thermodynamics, Tata McGraw Hill
2. R K Rajput: A Text Book of Engineering Thermodynamics, Laxmi Publications, New Delhi
3. C P Arora: Refrigeration and Air conditioning, Tata McGraw Hill.

Sub Code: **ME302A4** **Credit: 1 (L-0, T-0, P-2)**

FLUID MECHANICS LAB

Course Objective:

1. Understand the concept of various principles and mechanisms of fluid mechanics.
2. Understand the concept of working of pelton, francis, Kaplan turbine.
3. Convert the theoretical knowledge of fluid mechanics into practical knowledge.

Pre-requisites: Element of Mechanical Engineering, Fluid Mechanics, Fluid Mechanics & Hydraulic Machines.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	be able to verify the Bernoulli's equation.
CO2	be able to demonstrate the working of various fluid & Hydraulics machines.
CO3	be able to evaluate the performance of turbines and pumps.

Fluid Properties: Viscosity measurement by red wood viscometer.
Fluid statics: Determination of metacentric height, stability and equilibrium of floating and submerged bodies.
Fluid Pressure: Calibration of pressure gauges.
Dynamics of Fluid Flow: Application of Bernoulli's equation –pitot tube, venturimeter, orifice meter and nozzle.
Notches and weirs: Discharge over various notches, coefficient of discharge of V-notch, rectangular notch, trapezoidal notch.
Flow through pipes: Losses in pipe flow, major losses (loss due to friction).
Impact of Jet on stationary and moving plates: Force exerted by the jet on a stationary plate, on hinged plate and on moving plates.
Hydraulic Turbines: Introduction of Impulse and Reaction turbines. Performance testing of different turbine such as Tangential flow (Pelton turbine), Radial and mixed flow (Francis turbine), and axial flow (Kaplan turbine).
Hydraulic Pumps: Performance testing of centrifugal pump- Work done, Heads generation, discharge, efficiencies, Specific speed, Priming, Characteristic curves etc. Performance testing of reciprocating pumps- Work done, Heads generation, discharge, slip, efficiencies etc.

The above are the broad area of conduction of experiments. However the specific lists of experiments are the following. Students are required to perform minimum 12 experiments during the Lab in a semester.

List of Experiments:-

1. Determination of hydraulic power input, power output and overall efficiency of Pelton turbine.
2. Determination of output power and efficiency of a Francis turbine.
3. Determination of BP, WP, overall efficiency of Kaplan turbine.
4. Measurement of losses for pipes in different sections using pipe friction apparatus.
5. Determination of theoretical and actual co-efficient of discharge for a V-notch, rectangular notch, trapezoidal notch.
6. Experimental validation of Bernoulli's theorem.
7. Determination of Meta-centric height.
8. Determination of velocity of flow for fluid using pitot tube apparatus.
9. Determination of force exerted by jet of water on vanes.
10. Determination of kinematic viscosity by red wood viscometer.
11. Determination of overall efficiency of centrifugal pump.
12. Determination of total head, discharge, power output, shaft output, pumps efficiency, overall efficiency and volumetric efficiency of reciprocating pump.
13. Calibration of pressure gauges.

Reference books:

1. R.K.Bansal: Fluid Mechanics and Hydraulic Machines, Laxmi Publication.
2. D.S Kumar: Fluid Mechanics and Fluid Power Engineering, S. K . Kataria & sons.
3. S.K.Agarwal: Fluid Mechanics and Machinery, TMH.
4. S.K.Som, G.Biswas: Introduction to Fluid Mechanics, TMH.

Sub Code: **ME301A9** **Credit: 1 (L-0, T-0, P-2)**

INDUSTRIAL TRAINING-I

Course Objective: To familiarize the students with the actual operation in industry.

Pre-requisites: Knowledge of basics of Mechanical engineering.

Course Outcomes (CO): On Successful Completion of the course:

CO	STATEMENT
CO1	Visualize the practical application of mechanical equipments.
CO2	Able to relate the theoretical knowledge with practical use.
CO3	Able to develop new concept of operations.

Students will carry out Industrial Training I of two weeks after the completion of 4th semester during summer vacation. Report and PPT to be evaluated by the department in 5th semester examination.

Sub Code: **BA346A1** **Credit: 2 (L-2, T-0, P-0)**

INDUSTRIAL MANAGEMENT

Questions to be set: 05 (All Compulsory)

Course Objective: To provide basic knowledge of functions of management along with their practical implications.

Pre-requisites: NIL.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	To provide basic knowledge and application of functions of management.
CO2	To help students to understand and apply principles of management evolved by pioneers of management.
CO3	To enable students to apply basic quantitative techniques for making decisions related to operations management.
CO4	To help student apply various techniques for optimal production management.
CO5	To apply concepts of materials management for maintaining optimal inventory.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Philosophy and Development of Management thought. Concept and definition of management, Functions and Roles of Management, Social Responsibilities of Management.	3	1		
	Assignment topics			1		
Module 2: **Pioneers in Management**	In class	Taylor's Scientific Management, Contribution of Henry Fayol, Maslow, McGregor, Gilbreth and Mayo.	3	2		
	Assignment topics			2		
Module 3: **Quantitative Techniques in Managerial Decisions**	In class	Concept of budget and budgetary control. Time-event network analysis; ABC Analysis, Break-even Analysis; Decision Tables; Concept of productivity, measuring productivity, Use information technology	5	3		
	Assignment topics			3		
Module 4: **Production Management**	In class	Types of production; Types of Planning, Manufacturing Planning; Production planning, Scheduling; Work study & Method Study; Systems of wage payments, bonus, Automation. Organization of production, planning and control department.	5	4		
	Assignment topics			4		
Module 5: **Materials Management**	In class	Practice of purchasing and materials management, quality, Inventory Management, EOQ model; Value Analysis and Value Engineering.	4	5		
	Assignment topics			5		

Text books:

1. H. Koontz and H. Weihrich, "Management", McGraw Hill.
2. Dobler W.D. "Purchasing & Materials Management", TMHC, New Delhi.

Sub Code: **ME305A1** **Credit: 4 (L-3, T-1, P-0)**

HEAT TRANSFER

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To teach students the basic principles of conduction, radiation, and convection heat transfer.
2. To extend the basic principle of conservation of energy to systems which involve conduction, radiation, and heat transfer.
3. To train students to identify, formulate and solve engineering problems involving all modes of the heat transfer.

Pre-requisites: Basic Thermodynamics and Calculus and differential equations.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Develop and analyze the mathematical models for heat transfer by conductions in various engineering problems.
CO2	Analyze and design the extended surface to cool the engineering devices.
CO3	Predict the rate of heat transfer by convection between a solid and an internal or external fluid flow.
CO4	Predict the rate of heat transfer by radiation between solids
CO5	Analyze and design various heat exchange devices required for aforesaid applications

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Heat Conduction**	In class	Modes of heat transfer – conduction, convection & radiation, laws of heat Transfer, thermal conductivity, heat transfer coefficient, concept of thermal resistance. Generalized one dimensional heat conduction equation in rectangular, cylindrical and spherical co-ordinates system, simple steady state problems in heat conduction without and with heat generation.	8	1		
	Assignment topics	Numerical Questions				
Module 2: **Extended Surfaces and Unsteady Conduction**	In class	Extended Surfaces: Types of fins, heat transfer from fins, fin performance – fin efficiency and fin effectiveness,	6	2		
	Assignment topics	Unsteady Conduction: Unsteady heat conduction for bodies with negligible temperature gradients – lumped system analysis.				
Module 3: **Convection**	In class	Numerical Questions	7	3		
	Assignment topics	Free convection: Principles of natural convection, dimensionless parameters and empirical correlations for free convections.				
Module 4: **Radiation**	In class	Forced convection: Convective heat transfer in external flows, velocity and thermal boundary layer, drag coefficient for flow over a flat plate, heat transfer coefficient for flow over a flat plate, Reynolds – Colburn analogy, thermally fully developed flow through a pipe subjected to (i) constant surface heat flux and (ii) constant surface temperature.	8	4		
	Assignment topics	Numerical Questions				

Module 5: **Heat exchanger**	In class	Nature of thermal radiation, emission characteristics – absorptivity, transmissivity and reflectivity, emissive power, emissivity, radiation from real surface, solid angle and intensity of radiation, heat exchange by radiation between two black surface elements and two finite black surfaces, concept of shape factor, radiation heat transfer through two diffuse gray surfaces, radiation network, radiation shields.	7	5		
	Assignment topics	Numerical Questions				

Text books:

1. D. S. Kumar: Heat And Mass Transfer, S. K. Kataria & Sons
2. J. P. Holman.: Heat Transfer, McGraw – Hills
3. M. N. Ozisik: Heat Transfer- A Basic Approach, Mc- Graw Hills
4. C. P. Kothandaraman and Subramanyan: Heat and Mass Transfer Data Book, New age Int.

Reference books:

1. S. C. Arora, S Domkundwar: Heat and Mass Transfer, Dhanpat Rai & Sons

Sub Code: **ME306A1** **Credit: 4 (L-3, T-1, P-0)**

MACHINE DESIGN-II

Questions to be set: 05 (All Compulsory)

Course Objective: Machine Design help students understand the fundamentals of designing the most commonly used parts, elements and units of various machines. Upon completion of this course, the student should be able to:

1. Make proper assumptions, perform correct analysis, and consider technical, safety, legislative and other issues in design and development of mechanical systems.
2. Acquire the fundamental knowledge of design procedures and correlate with the engineering applications.
3. Apply the fundamentals of stress analysis, theories of failure and material science in the design of machine components.
4. Derive and analyze the mode of failure and applied stresses in the components.
5. Demonstrate creativeness in designing new systems, components and processes in the field of engineering in general and mechanical engineering in particular.

Pre-requisites: Basics of strength of materials & material science, elementary design.

Course Outcomes (CO): On successful completion of the course student will be able to:

CO	STATEMENT
CO1	Make proper assumptions, perform correct analysis, and consider technical, safety, legislative and other issues in design and development of mechanical systems.
CO2	Acquire the fundamental knowledge of design procedures and correlate with the engineering applications.
CO3	Apply the fundamentals of stress analysis, theories of failure and material science in the design of machine components.
CO4	Derive and analyze the mode of failure and applied stresses in the components.
CO5	Demonstrate creativeness in designing new systems, components and processes in the field of engineering in general and mechanical engineering in particular.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Spur Gears and Helical gears**	In class	**Spur Gears**: Review of involute characteristics, standard systems of gear tooth, force analysis, gear tooth failures , loads on gear teeth- dynamic loads, beam strengths, Lewis equation, Lewis form factor, effective load on gear teeth, dynamic load, wear strength, Buckingham's equation, gear design for maximum, power transmitting capacity. **Helical gears:** Terminology, virtual number of teeth, tooth proportions, force analysis, beam strength, effective load, wear strength.	8	1, 2, 3, 4, 5		
	Assignment Topics	Problems solving				
Module 2: **Bevel Gears and Worm Gears**	In class	**Bevel Gears:** Terminology, force analysis, beam strength, effective load, wear strength. **Worm Gears**: Terminology, proportions of worm and worm gears, force analysis, strength rating and wear rating of worm gears, thermal considerations.	7	1, 2, 3, 4, 5		
	Assignment Topics	Problems solving				

Module 3: **Springs**	In class	**Springs:** Types, materials, end connections fort helical springs, stresses and deflection of helical springs of circular wire, design of springs subjected to static and fluctuating load, springs in series and parallel, concentric springs, helical torsion springs, leaf springs, nipping of leaf springs, length of leaves.	7	1,3		
	Assignment Topics	Problems solving				
Module 4: **Rolling contact bearings**	In class	Types, Stribeck's equation, static and dynamic carrying capacity, equivalent bearing load, load- life relationship, selection of radial bearings, reliability of a bearing, lubrication of ball and roller bearings.	7	1, 2, 3, 5		
	Assignment Topics	Problems solving				
Module 5: **Journal Bearing**	In class	Hydrodynamic lubrication and Reynold's equation, wedge film and squeeze film journal bearing, bearing characteristic number and bearing module for journal bearing, co-efficient of friction, critical pressure, Sommerfield Number, Heat generated in journal bearing, Design procedure.	7	1, 2, 3, 5		
	Assignment Topics	Problems solving				

Text books:

1. V. B. Bhandari: Design of machine elements, TMH
2. P. Kannaiah: Machine Design, Scitech Publications (India) Pvt. Ltd.
3. P. C. Sharma and D. C. Agarwal: Machine Design, S. K. Kataria and sons
4. R. S. Khurmi and J.K. Gupta: Machine Design, S Chand Publications
5. K. Mahadevan and K. Balaveera reddy: Design Data Handbook (SI Units), KREC, Surathkal

Reference books:

1. J. Shigley: Mechanical Engineering Design, McGraw Hill
2. Siegel, Maleev & Hartman: Mechanical Design, International Textbook Co.
3. Sadhu Singh: Machine Design, Khanna Publishers.
4. Ghosh: Practical Machine Design, S. Bhattacharya Co.
5. Spotts: Design of Machine Elements, Prentice Hall (India)
6. Abdulla Ed Shariff: Handbook of properties of Engineering Materials and Design Data for Machine Elements, Dhanpat Rai & sons.

Sub Code: **ME303A4** **Credit: 1 (L-0, T-0, P-2)**

MACHINE DYNAMICS LAB

Course Objective:

1. Apply skills and understanding, and be able to solve standard vibration problems that occur in mechanical engineering applications.
2. Appreciate the concept of machine Dynamics
3. Come up with innovative ideas.

Pre-requisites: TOM I,TOM II,MD II,& Basic Concept of Machine Vibration.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	To verify equation of motion and calculate the natural frequency of free/forced vibrating SDOF undamped and damped systems.
CO2	To evaluate the power transmission efficiency of gear train.
CO3	To test the performance of different Governors.
CO4	To perform static and dynamic balancing, effects of Gyroscopic couple and coriollis component of acceleration of rotating masses.
CO5	To understand the concept of conversion of motion types using cam and follower mechanism.

Governors-Performance testing of Porter, Hartnell and Hartung governors- controlling force, stability, sensitiveness isochronism, capacity and coefficient of insensitiveness, effort and power of governors.
Gyroscopic effects- Study of Gyroscopic effects of a rotating disc.
Balancing of rotating masses-static and dynamic balancing of several masses rotating in the same plane and balancing of several masses rotating in different planes.
Undamped free vibration: Natural frequency of various spring-mass, torsional and other systems with different types of restoring forces.
Damped free vibration: Viscous damping; response of overdamped, critically damped and underdamped systems
Forced vibration of SDOF systems: Steady state forced vibration due to external harmonic force.
Whirling of shaft: Critical speed of a light shaft having a single disc – without damping and with damping
Cam and Follower: Generation of cam profile with knife edge follower.
Gear Train: Power transition using epicyclic gear train- gear ratio, torque, efficiency.
Bearing: Operation of journal bearing**.**
Coriollis acceleration: Determination of coriollis component of acceleration of a rotating as well as translating body.

The broad areas for conduct of experiments are lenlisted above. However, the specific lists of experiments are as follows. Students are required to perform minimum 12 experiments during the Lab in a semester.

List of Experiments:-

1. To perform experimental studyon free torsional vibration- single rotor and Double Rotor.
2. To study the damped torsional oscillations for determining the damping coefficient.
3. To determine the radius of gyration of a given bar by using bi-filler suspension.
4. To study free and forced vibration of equivalent spring mass system with and without damping.
5. Determination of gyroscopic effect of a rotating disc and calculation of gyroscopic couple in a motorized gyroscopic set-up.
6. To study the longitudinal vibration of helical spring and to determine the theoretical and actual frequencies of oscillation .
7. To study Static and dynamic balancing of masses.
8. (a) Determination and comparison of experimental periodic time with theoretical periodic time for a simple pendulum.
   (b) To determine the radius of gyration of a compound pendulum and to verify its expression of time-

period.

9. Plotting of follower displacement Vs. angle of cam rotation curves in a Cam-analysis machine.
10. Determination of various characteristic curves in a Universal Governor apparatus.
11. Determination of epicyclic gear-ratio and verification of torque equation in an epicyclic gear-Train apparatus.
12. Determination of Coriollis component of acceleration.
13. Determination of frequency and mode of Whirling of shaft
14. Study of pressure profile on journal bearing apparatus.

References books:

1. V. Ramamurti: Mechanical Vibrations practice with basic theory, Narosa
2. S. S. Rattan: Theory of Machines, TMH

Sub Code: **ME304A4** **Credit: 1 (L-0, T-0, P-2)**

HEAT TRANSFER LAB

Course Objective:

1. To verify the basic equations related with conduction, radiation, and convection heat transfer.
2. To train students to identify, formulate and solve engineering problems involving all modes of the heat transfer.

Pre-requisites: Basic Thermodynamics, Heat Transfer and Calculus and differential equations.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	To practically understand the concepts of conduction, radiation, and convection heat transfer.
CO2	To verify the basic equations related with conduction, radiation, and convection heat transfer.
CO3	To design and evaluate the performance of different heat exchangers.
CO4	To understand the concept of Condensation and boiling.
CO5	To develop mathematical model and evaluate the heat transfer for different area of applications.

Heat conduction: Simple steady state problems in heat conduction without and with heat generation – plane wall, long hollow cylinder, hollow sphere, composite slab, composite cylinder and composite sphere, overall heat transfer coefficient. Extended Surfaces: Types of fins, heat transfer from fins, fin performance – fin efficiency and fin effectiveness,

Forced convection: Thermally fully developed flow through a pipe subjected to (i) constant surface heat flux and (ii) constant surface temperature, dimensional analysis applied to forced convection, empirical correlations

Free convection: Dimensional analysis applied to free convection, dimensionless parameters and empirical correlations for free convections.

Condensation and boiling: Condensation heat transfer, dropwise condensation and filmwise condensation, condensation on horizontal tubes, boiling heat transfer, regimes of boiling, nucleate and film boiling, correlations of boiling heat transfer.

Heat exchanger: Temperature distribution in heat exchangers, overall heat transfer coefficient and fouling factor, LMTD method for heat exchanger analysis - parallel flow and counter flow , correction for LMTD in cross-flow, ε – NTU method for heat exchanger analysis – parallel and counter flow

Radiation: Nature of thermal radiation, emission characteristics – emissive power, emissivity, radiation from real surface, heat exchange by radiation between two black surface elements.

The above are the broad area of conduction of experiments. However the specific lists of experiments are the following. Students are required to perform minimum 12 experiments during the Lab in a semester.

List of Experiments:-

1. To study the heat transfer (conduction) through insulating powder.
2. To study the heat transfer through pin fin.
3. To study the heat transfer through insulating slab.
4. To study the heat transfer through lagged pipe.
5. To study the performance of a finned tube heat exchanger.
6. To study the heat transfer in shell and tube heat exchanger.
7. To Study of drop wise and film wise condensation.
8. To study the heat transfer through composite wall.
9. Determination of emissivity of test plate.
10. Determination of thermal conductivity of metal bar.
11. To study the Stefan Boltzmann apparatus.
12. Performance testing of parallel flow and counter flow heat exchanger.
13. Determination of heat transfer in Natural convection apparatus.
14. Determination of heat transfer in forced convection.

Reference books:

1. D. S. Kumar: Heat And Mass Transfer, S. K. Kataria & Sons
2. J. P. Holman.: Heat Transfer, McGraw – Hills
3. M. N. Ozisik: Heat Transfer- A Basic Approach, Mc- Graw Hills
4. C. P. Kothandaraman & Subramanyan: Heat and Mass Transfer Data Book, New age Int.
5. S. C. Arora, S Domkundwar: Heat and Mass Transfer, Dhanpat Rai & Sons.

Sub Code: **ME302A5** **Credit: 1 (L-0, T-0, P-2)**

MINI PROJECT

Course Objective: To motivate the students for practical application of knowledge gain

Pre-requisites: Knowledge of Mechanical engineering subjects taught.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Utilize the theoretical knowledge on actual application.
CO2	Visualize the practical application of mechanical equipments.
CO3	Able to develop new concept for various applications.

Minor project should be done by the students in 6^{th} semester for which a teacher is assigned to the student(s) under whom he/she/they will work. Minimum contact hour per week is 4 hrs.

Sub Code: **ME401A6** **Credit: 10 (L-0, T-0, P-20)**

MAJOR PROJECT- PHASE-I

Course Objective: To familiarize the students with Industrial technical/research based problems.

Pre-requisites: Knowledge of basics of Mechanical engineering.

Course Outcomes (CO): On Successful Completion of the course:

CO	STATEMENT
CO1	Able to Identify and resolve the actual industrial problems
CO2	Come up with innovative ideas.
CO3	Visualize the practical application of mechanical equipments.
CO4	Able to relate the theoretical knowledge with practical use.
CO5	Able to develop the interpersonal and managerial skills.

7th semester student(s) will have to undergo a Industrial Project preferably on live industrial problems. However the student(s) can do Research Based Project in any R&D lab/organization/institution of good repute. The project work will be evaluated at the place of work/organization by the external project supervisor out of 100. Further the college will also assign a project supervisor. The project work will be evaluated at two stages in the department, namely (i) Internal evaluation (out of 100) and (ii) external evaluation (out of 100). For external evaluation an external examiner is required from outside the college.

Sub Code: **ME401A9** **Credit: 1 (L-0, T-0, P-2)**

INDUSTRIAL TRAINING-II

Course Objective: To familiarize the students with the actual operation in industry.

Pre-requisites: Knowledge of basics of Mechanical engineering.

Course Outcomes (CO): On Successful Completion of the course:

CO	STATEMENT
CO1	Visualize the practical application of mechanical equipments.
CO2	Able to relate the theoretical knowledge with practical use.
CO3	Able to develop new concept of operations.

After completion of VIth semester, students do their Industraial Training II of four weeks during summer vacation at different industries/establishments. Report and PPT to be evaluated by the department in 7th semester examination.

Sub Code: **ME402A6** **Credit: 09 (L-0, T-0, P-18)**

MAJOR PROJECT- PHASE-II

Course Objective: To familiarize the students with Industrial technical/research based problems.

Pre-requisites: Knowledge of basics of Mechanical engineering.

Course Outcomes (CO): On Successful Completion of the course:

CO	STATEMENT
CO1	Able to Identify and resolve the actual industrial problems
CO2	Come up with innovative ideas.
CO3	Visualize the practical application of mechanical equipments.
CO4	Able to relate the theoretical knowledge with practical use.
CO5	Able to develop the interpersonal and managerial skills.

8th semester student(s) will have to undergo Industrial Project preferably on live industrial problems. However the student(s) can do Research Based Project in any R&D lab/organization/institution of good repute. The project work will be evaluated at the place of work/organization by the external project supervisor out of 100. Further the college will also assign a project supervisor. The project work will be evaluated at two stages in the department, namely (i) Internal evaluation (out of 100) and (ii) external evaluation (out of 100). For external evaluation an external examiner is required from outside the college.

MECHANICAL ENGINEERING (PROGRAM ELECTIVES)

Sub Code: **ME201A3** **Credit: 4 (L-3, T-1, P-0)**

MATERIAL SCIENCE

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able to:

1. Understand the Crystal Structure of Crystalline and amorphous solids and its process of determination.
2. Understand the different phases in solids, Iron-Carbon equilibrium diagram.
3. Able to understand and appreciate how heat treatment is beneficial in changing the various properties of the materials.
4. Able to differentiate between Cast Iron and Steel and their practical applications and lastly learn about the properties and uses of Non-ferrous Alloys and Non-metallic materials

Pre-requisites: Basics of mechanical engineering.

Course Outcomes (CO): On successful completion of the course students will be able to:

CO	STATEMENT
CO1	Identify crystal structures for various materials and understand the defects in such structures.
CO2	Gain basic understanding of surface morphology of various materials.
CO3	Understand various phases of iron using iron-carbon equilibrium diagram.
CO4	Gain understanding of various heat treatment processes.
CO5	Understand the properties of different types of cast iron, steel, non-ferrous alloys and non-metallic materials and their practical applications.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Crystal Structure:**	In class	Crystalline and amorphous solids, unit cells – types, atomic packing factor, density (simple calculations), crystal imperfections – types, identification of planes and Miller indices.	8	1		
	Assignment topics	Various diagram, Numerical				
Module 2: **Metallography and Solidification**	In class	Specimen preparation, light microscope, electron microscope. Nucleation, single crystal growth and dendritic growth; solid solution – types.	7	2		
	Assignment topics	Various diagram, Numerical				
Module 3: **Phases in Solids and Iron Carbon System**	In class	Gibbs phase rule, Lever rule, binary phase diagram construction – their development for components with complete solubility and partial solubility, invariant reactions, Inter-metallic compounds. Carbon diagrams with emphasis on invariant reactions, isothermal and continuous cooling transformation diagrams (TTT & CCT curves).	10	3		
	Assignment topics	Various diagram, Numerical				
Module 4: **Heat Treatment of Ferrous Alloys and Classification**	In class	Annealing–types, normalizing, homogenizing, hardening – quench hardening, case hardening, hardenability and Jominy hardenability test, Tempering – types, austempering and martempering. Composition, microstructure, properties and applications, effects of alloying elements on cast iron	7	4		

and Types of Cast Iron and Steel		and steel. Principles of precipitation or age hardening				
	Assignment topics	Various diagram				
Module 5: **Non-metallic materials**	In class	Properties and uses of polymers, ceramics and important composite materials.	4	5		
	Assignment topics	Various properties				

Text Books:

1. W.F. Smith: Principles of Material Science and Engineering, McGraw Hill
2. R.B. Choudhary: Material Science and metallurgy, Khanna Publishers
3. K.G. Aswani: A text Book of Material Science, S. Chand & Co

Reference books:

1. Y. Lakhtin: Engineering Physical Metallurgy, Mir Publishers, Moscow.
2. Avner Sidney: Introduction to Physical Metallurgy, Tata McGraw Hill

Sub Code: **ME202A3** **Credit: 4 (L-3, T-1, P-0)**

ELECTRIC VEHICLE FUNDAMENTALS

Questions to be set: 05 (All Compulsory)

Course Objective: This course will be a first level course on electric vehicle. Students will be able to understand the operation of battery driven electric vehicle. Upon completion of this course, the student should be able to:

1. To study the characteristics behavior of engine, electric motor, controller and energy storage devices for vehicle propulsion systems.
2. To study and analyze the renewable energy systems to develop zero emission vehicles.

Pre-requisites: Knowledge of Engineering Mechanics, Motors, Automobile basics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Analyze the challenges of electric vehicle over conventional IC engine powered vehicles.
CO2	Apply the degree of hybridization and alternate powertrain architectures for a conventional system.
CO3	Evaluate the characteristics and maximum power demand of electric and hybrid drive propulsion system.
CO4	Analyze the performance and characteristics of battery and electronics converters for the vehicle propulsion systems.
CO5	Analyze the performance and characteristics of fuel cell for the vehicle Propulsion system.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Electric Vehicles**	In class	Architecture of an electric vehicle, essentials and performance of electric vehicles – Traction motor characteristics, tractive effort, transmission requirements, vehicle performance.	8	1		
	Assignment topics	Energy consumption, advantage and limitations.				
Module 2: **Hybrid Vehicles**	In class	Hybrid electric drivetrains -Concepts, architecture, design, control strategies.	6	2		
	Assignment topics	Merits and demerits				
Module 3: **Electric Propulsion Systems**	In class	DC motor drives, induction motor drives, permanent magnet motor drives.	6	3		
	Assignment topics	Switched reluctance motor drives.				
Module 4: **Energy Storage Devices**	In class	Electrochemical batteries –Reactions, thermodynamic voltage, lead-acid batteries, nickel based batteries, lithium based batteries, flywheel and ultra-capacitors, Battery management systems.	8	4		
	Assignment topics	Range calculation				
Module 5: **Fuel Cell and Solar Powered Vehicles**	In class	Fuel cell thermodynamics, operating principle, fuel cell technologies, fuel reforming, hydrogen production and storage, open circuit voltage flow rate testing and evaluation. Photovoltaic cell, maximum power point tracking, solar powered accessories.	8	5		
	Assignment topics	Hybrid solar vehicles. Fuel Cell testing and evaluation.				

Text Books:

1. Mehrdad Ehsani, YiminGao, Sebastien E. Gay and Ali Emadi: Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2009.
2. Iqbal Husain: Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011.2009.

Reference Books:

1. Seref Soylu: Electric Vehicles -The Benefits and Barriers, InTech Publishers, Croatia, 2011.
2. AuliceScibioh M. and Viswanathan B.: Fuel Cells –Principles and Applications, University Press, India, 2006.
3. Barbir F.: PEM Fuel Cells: Theory and Practice, Elsevier, Burlington, 2005.
4. James Larminie and John Loury: Electric Vehicle Technology-Explained, John Wiley & Sons Ltd., 2003.
5. Babu A.K.: Electric & Hybrid Vehicles, Khanna Publishing House, Delhi.

Sub Code: **ME203A3** **Credit: 4 (L-3, T-1, P-0)**

MANUFACTURING AND METROLOGY

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able to:

1. Acquire basic concept of various non-traditional machining processes.
2. Develop awareness, knowledge and basic skill necessary for the reliable measurement applications.
3. Understand the measurement applications for Geometric Dimensioning and Tolerance (GD&T) and assessment of measurement quality.
4. Differentiate between metrology and experimental engineering.

Pre-requisites: Basics of manufacturing process, measurements and measuring devices.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Apply the knowledge on machining electrically conductive material through electrical energy in non-traditional machining process
CO2	Apply the knowledge and basic skill necessary for the reliable measurement applications
CO3	Understand the measurement applications for Geometric Dimensioning and Tolerance (GD&T) and assessment of measurement quality
CO4	Understand the methods and instruments of length, angle, gear, thread measurements etc.
CO5	Understand the difference between metrology and experimental engineering

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Non-traditional Machining processes**	In class	Basics understanding about working and application of non-traditional machining processes viz. WJM, AJM, AWJM, USM,	6	1		
	Assignment topics	ECM, EDM, LBM, IBM, and hybrid machining				
Module 2: **Introduction to Engineering Metrology**	In class	Basic concepts like Accuracy, Precision, Hysteresis, Sensitivity, Errors in measurement, Interchangeability.	2	2		
	Assignment topics	Line Standards, End Standard, Wavelength Standard.				
Module 3: **Limit, Fit, Tolerances and Comparator**	In class	Limit, Fits, Tolerances, Indian Standard (IS 919-1963), Numerical	8	3,5		
	Assignment topics	Mechanical comparator, Electrical and Electronics Comparator, Solex pneumatic gauge.				
Module 4: **Gauges**	In class	Introduction, Types of Gauges–Plain Plug Gauges, Plain Ring Gauges, Snap Gauges, Taylor's Principle for Gauge design, Gauge Maker's tolerance, Numerical.	6	3,5		
	Assignment topics	Grades, Wringing, and Selection of Slip Gauges for the required dimension				
Module 5: **Screw thread Metrology and Measurement**	In class	Introduction, Errors in threads, Measurement of major diameter using Bench Micrometer, Measurement of Minor diameter using Micrometer with Vee pieces, Measurement of Effective diameter–Thread Micrometer method, two wire and three wire method.	4	3,4,5		

of Surface Finish	Assignment topics	Surface finish measuring instruments–Tomlinson Surface Meter, Taylor– Hobson Talysurf, Analysis of Surface Traces– RMS and CLA methods				

Text Books:

1. P. N. Rao: Manufacturing Technology – Metal Cutting and Machine Tools; TMH,
2. R. K. Jain: Engineering Metrology, Khanna Publishers–Delhi
3. A. S. T. M. E.: Handbook of Industrial Metrology, Prentice Hall of India, New Delhi.

Reference Books:

1. K. J. Hume: Engineering Metrologym, Kalyani Publisheres, Ludhiana
2. K.W. B Sharp: Practical Engineering Metrology, Pitman, London
3. M. R. Taher: Metrology of Measuring Instruments, E.L.B.S.

Sub Code: **ME204A3** **Credit: 4 (L-3, T-1, P-0)**

TOOL ENGINEERING AND DESIGN

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To familiarize the student with tool nomenclature and cutting forces and give knowledge about the tool geometry.
2. To impart knowledge on tool materials, tool life and tool wear.
3. To educate students on failure analysis of cutting tools.
4. To impart the knowledge about the mechanism of chip formation, heat distribution and thermal aspects of machining.

Pre-requisites: Basics knowledge of tool geometry, tool signature, functions of various angles in single point and multi point cutting tool. Knowledge of Trigonometry.

Course Outcomes (CO): On Successful Completion of the course students will be benefitted in the following manner:

CO	STATEMENT
CO1	Student will have a clear understanding about the various tool nomenclatures of cutting tool.
CO2	Students will acquire knowledge about various cutting tool materials and their characteristics
CO3	Students will acquire the knowledge in designing a high production cutting tool
CO4	Student will have a clear understanding about the various methods used to reduce the cost of machinery.
CO5	Students will acquire knowledge about the various modes of failure of cutting tool.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Tool Geometry:**	In class	Introduction, basic shape of cutting tools, tool point reference system and tool axis reference, machine reference system, geometry of single point cutting turning tools: location of cutting edges, orientation of face and flank surfaces, interrelationship between different systems of rake angle nomenclature, method of slope for rake angles, method of master line for rake angles, method of circle diagram for rake angle conversion in cutting tool geometry.	8	1		
	Assignment topics	Geometry of twist drills , working system and rake and clearance angles of twist drill bit.				
Module 2: **Cutting Tool Materials**	In class	Introduction of cutting tool materials, properties, tool life.	8	2		
	Assignment topics	Performance and condition of use of HSS, cemented carbides, coated carbides, ceramic and diamond cutting tool.				
Module 3: **Design of Single Point Cutting Tool**	In class	Design of tool shanks for strength and rigidity, design of Tool-tips, optimization of tool shape: clearance angle, rake angle, inclination angle, principal cutting edge angle (PCEA), Auxiliary cutting edge angle (ACEA), nose radius.	8	2		
	Assignment topics	Design of chip breakers: geometry of chip- breaking action, chip breaker types.				
Module 4:	In class	Introduction, features of high production cutting tools: use of negative rake for edge strengthening principles of	6	3,4		

Design of High Production Cutting Tools		restricted contact, compounding of cuts, typical high production cutting tools.				
	Assignment topics	Kolesov tool, modified Kolesov tool with retraced cutting edge, improved designs of milling cutters, Schmidt's double radial rake cutter, chip breaking grooves in cutters.				
Module 5: **Heat Generation and cutting temperature in Machining**	In class	Introduction, location and cause of heat generation in machining, Effect of cutting temperature on job and tool, Effect of high cutting temperature on product quality, Effect of high cutting temperature on cutting tool. Analytical methods of evaluating cutting temperatures, Measurement of cutting temperatures.	6	5		
	Assignment topics	Possible favorable effects of high temperature cutting, Purpose of determination of cutting temperature.				

Text Books:

1. A. Bhattacharyya; Metal Cutting Theory and Practice, New Central Book Agency (P) Ltd.
2. Edward M. Trent & Paul K. Wright; Metal Cutting, Butterworth & Heinemann.

Reference Books:

1. Cyril Donaldson, George H LeCain, VC Goold; Tool Design, Tata McGraw Hill
2. BL Juneja, GS Sekhon; Fundamentals of Metal Cutting and Machine Tools, New Age International (P) Ltd.

Sub Code: **ME205A3** **Credit: 4 (L-3, T-1, P-0)**

INTERNAL COMBUSTION ENGINES

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To study the thermodynamics, combustion, heat transfer, friction and other factors affecting engine power, efficiency and emissions,
2. To introduce students to the environmental and fuel economy challenges facing the internal combustion engine,
3. To introduce students to future internal combustion engine technology and market trends.

Pre-requisites: Knowledge of Thermal Engineering, Basics of chemical Engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Investigate the working and performance of various I. C. engines and model the performances based on ideal cycles.
CO2	To predict performance and fuel economy trends in I.C. engines with good accuracy, work on eliminating the existing inefficiencies in I.C. engines.
CO3	To identify the right quality of fuel and fuel supply systems for different I.C. engines
CO4	To conduct investigation of combustion phenomenon happening inside the combustion chamber of I.C engines and correlate it with the engine performance.
CO5	To set-up and run engines in controlled laboratory environments and also conduct engine dynamometer experiments.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Ideal Cycles and their analysis**	In class	Air Standard cycles & their analysis (Otto, Dual and Diesel cycles), Expression for Work done, mean effective pressure and efficiency of Otto, Diesel and Dual Cycles, Comparison of efficiencies.	6	1		
	Assignment topics	Numerical Problems related to Air standard cycle				
Module 2: **Actual Cycles and their Analysis**	In class	Fuel air cycles and their analysis, Actual cycles and their analysis, Valve timing diagrams for 4-stroke S.I. and C.I. engines.	7	2		
	Assignment topics	Numerical Problems related to Fuel Air cycle				
Module 3: **Fuels and its supply system for SI and CI engine:**	In class	Important qualities of IC engine fuels, rating of fuels, Carburetion, mixture requirement for different loads and speeds, simple carburetor and its working, MPFI, types of injection systems in CI engine, fuel pumps and injectors, types of nozzles, spray formation	7	3		
	Assignment topics	Types of carburetors				
Module 4: **Combustion in I.C. Engines**	In class	Combustion S.I. Engines - Introduction, Ignition Limits, Stages of combustion in S.I. Engines, Effect of engine variables on ignition lag and flame propagation, Factors influencing the flame speed, Rate of pressure rise, Cycle variations, Abnormal Combustion, Detonation or knocking, Effect of engine variables on knock or detonation, Control of detonation, Abnormal combustion knock- surface ignition, S.I. Stages of combustion in C.I.	9	4		

		Engines, Air fuel ration in C.I. Engines, Delay period, Variables affecting delay period, Diesel knock, Methods of controlling Diesel knock,				
	Assignment topics	Comparison of Knock in S.I. and C.I. Engine.				
Module 5: **Performance Parameters in I.C. Engine**	In class	Performance parameters, Basic Measurements, Measurements of speed, fuel consumption, air consumption, exhaust smoke, exhaust emission, brake power (Prony brake, rope brake) indicated power, friction power (Morse test, Willian's Line Method), Indicated Mean effective pressure, Brake mean effective pressure, Engine efficiencies – Air standards efficiency, Indicated and Brake thermal efficiencies, Mechanical efficiency	7	5		
	Assignment topics	Numerical Problems				

Text books:

1. Heinz Heisler, 'Advanced Engine Technology," SAE International Publications, USA, 1998.
2. Sharma and Mathur: I.C. Engines; Dhanpat Rai & Sons.

Reference books:

1. V. Ganeshan: I.C. Engines,
2. John B Heywood," Internal Combustion Engine Fundamentals", Tata McGraw-Hill 1988

Sub Code: **ME301A3** **Credit: 3 (L-3, T-0, P-0)**

AUTOMOBILE ENGINEERING

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able to:

1. To know and understand the various mechanisms that applies to the operation of an Automobile.
2. To appreciate new concepts in Automobile Engineering.
3. To develop ability to come up with innovative ideas.

Pre-requisites: Element of Mechanical Engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the working principle of I.C Engines and its different components and apply the skill to identify, di-assemble and assemble the components of I.C engine.
CO2	Apply the knowledge of gears and its terminology to design gears to be used in automobile gearboxes and Differential.
CO3	Apply the knowledge and skill to replace brake pads and clutch plates of an automobile.
CO4	Understand and know the working principle and types of suspensions systems, fuels supply system (MPFI), Ignition system, Superchargers and turbochargers used in automobile.
CO5	Able to come up with innovative ideas and methods that can be implemented on various components and working of an automobile system.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to the engine**	In class	Description of parts and their functions (cylinder block, crankcase, cylinder head, piston, piston rings, piston pin, Connecting rod, crankshaft, flywheel, valve and valve mechanisms, valve tappet clearance, overhead valve, eccentric rocker arm, camshaft drive)	8	1		
	Assignment topics	Types of I.C. Engines and material components.				
Module 2: **Ignition system and MPFI**	In class	Battery ignition system and Magneto ignition system. Introduction to multi point fuel injection. Supercharging and Turbo-charging.	10	2		
	Assignment topics	Application of supercharging and turbocharging in modern vehicles. Advantages and Limitations.				
Module 3: **Clutch and Cooling system**	In class	Operation of single plate clutch, multi-plate clutch, centrifugal clutch, Dry & Wet clutch.	10	3		
	Assignment topics	Methods of cooling (Direct cooling and Indirect cooling)				
Module 4: **Gearbox and Axle**	In class	Operation of Sliding mesh gearbox, constant mesh gearbox, synchro-mesh gearbox. Ackerman and Davis steering mechanisms, differential.	10	4		
	Assignment topics	Working principle of epicyclic gearbox. Introduction to front axle, Working principle of Hotchkiss drive and torque tube drive.				
Module 5: **Suspension systems and brakes**	In class	Types of suspension springs, leaf spring, coil spring, torsion bar. Front suspension and Rear end suspension. Function and Operation. Principle of mechanical and hydraulic brakes, disc brake, air brakes.	10	5		
	Assignment topics	Wheels and tyres, Emission control norms.				

Text Books:

1. Kirpal Singh: Automobile engineering (Vol. I & II), Standard publishers' distributors.
2. N. K. Giri: Automobile Mechanics, Khanna publishers.
3. V. Ganeshan: I. C. Engines, TMH publishers.

Reference Books:

1. S. Srinivasan: Automotive Mechanics, TMH publishers.
2. Jeffrey K. Ball & Richand Stone: Automotive Engineering Fundamentals, SAE International.

Sub Code: **ME302A3** **Credit: 3 (L-3, T-0, P-0)**

ADVANCED MANUFACTURING PROCESSES

Questions to be set: 05 (All Compulsory)

Course Objective: The objective of this course is to introduce the non-traditional machining, its process principle and applications and advanced forming processes.

Pre-requisites: Knowledge of traditional machining processes, forming processes.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	Understand the basic difference between non-traditional and traditional machining processes
CO2	Understand the need of advanced manufacturing processes and its classification
CO3	Understand the process principle of various non-traditional processes
CO4	Understand application of various non-traditional machining processes
CO5	Classify various advanced forming processes

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction**	In class	Introduction to Non-conventional machining process, Difference between conventional and non-conventional machining processes, need of advanced manufacturing processes. Classification of non-conventional machining processes.	4	1,2		
	Assignment topics	Case study				
Module 2: **Mechanical type NTM Processes**	In class	Introduction to water jet machining, process principle, derivation of power of water jet, applications, limitations. Introduction to abrasive water jet machining, process principle, derivation of MRR applications, limitations. Introduction to ultrasonic machining, process principle, derivation for Material removal rate, applications, numerical.	12	3,4		
	Assignment topics	Numerical				
Module 3: **Thermal type NTM Processes**	In class	Introduction to Electrical Discharge machining, process principle, derivation for MRR, Power generators, applications, limitations, Numerical. Introduction to Laser Beam machining, process principle, Laser types, applications, limitations. Introduction to Wire Electrical Discharge machining, process principle, applications, limitations, Introduction to Electron Beam machining, process principle, Vacuum pump, applications, limitations, Introduction to Ion Beam machining, process principle, applications, limitations.	10	3,4		
	Assignment topics	Numerical, Power generators, Wire Electrical Discharge Machining				
Module 4: **Chemical type NTM Processes**	In class	Introduction to Electro Chemical machining, process principle, derivation for MRR, applications, limitations, Numerical. Introduction to Chemical machining, process principle, applications, limitations, Numerical.	6	3,4		
	Assignment topics	Numerical.				

Module 5: **Advanced Forming Processes**	In class	Introduction to advanced forming. Classification, High rate energy forming, Explosive forming, Electro Hydraulic forming, magnetic pulse forming.	4	5		
	Assignment topics	Magnetic pulse forming.				

Text Book:

1. E. P. Degarmo, J. Temple Black and Ronald A. Kohser: Materials and Processes in Manufacturing, Prentice Hall of India
2. P. N. Rao: Manufacturing Technology (Metal Cutting & Machine Tools), TMH
3. R. K. Jain: Production Technology, Khanna Publishers
4. V. K. Jain: Advanced machining process, Allied

Reference Books:

1. Campbell: Principles of Manufacturing Materials and Processes, TMH
2. Lindberg: Processes and Materials of Manufacture-PHI
3. E. J. Weller: Non-Traditional Machining Process, Sosiety of Manufacturing Engineers Publishers, Michingan
4. Gary F. Benedict: Non-Traditional Manufacturing Process, Marcel Dekkar Inc. New York.

Sub Code: **ME304A3** **Credit: 3 (L-3, T-0, P-0)**

LATEST TRENDS IN MECHANICAL ENGINEERING

Questions to be set: 05 (All Compulsory)

Course Objective: The student will learn

1. To know and understand the use of IOT in the field of Manufacturing, agriculture, and energy management.
2. To know about the recent developments in thermos-fluid.
3. To know about the recent advancement in industrial automation and advancement considering mechatronics system, CNC, Rapid Prototyping, Smart materials for sensing, transportation, proper supply-chain management, and reliability.

Pre-requisites: Basic knowledge of Mechanical Engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Demonstrate the various uses of IOT in different sectors.
CO2	Develop new concepts in recent development in nano-fluid and nano-fluid energy conversion.
CO3	Develop idea of Rapid prototyping and Advances in Industrial Automation
CO4	Provide idea of next phase of transportation system
CO5	Describe block chain for industrial application

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Rapid Prototyping**	In class	Need of Rapid Prototyping, Basics of RP, Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative, Generic RP process. Stereo-lithography, Basic of CAD Modelling and Data Processing for RP, Fused Deposition Modelling, Extruder deposition System.	8	3		
	Assignment topics	Electron Beam melting, Laminated Object Manufacturing, 3D Printing				
Module 2: **Micromachining Techniques and Micro mechatronics System**	In class	Introduction to Jet EMM, Capillary drilling, 3D EMM, Laser micromachining technique by Nanosecond pulse micromachining, Picoseconds pulse micromachining, femto second. Introduction to Micro-sensors, Applications of micro-mechatronics systems. Pulse micromachining by Electron Beam micromachining-mechanism, importance of vacuum, process parameter, effect of cutting speed, machining of ferrite.	8	3		
	Assignment topics	micro-actuators, Micro-fabrication techniques LIGA process etching and micro-joining.				
Module 3: **Introduction to IOT, Block-Chain and Industrial Automation**	In class	Definition, Basic Concept of IOT, sensor Networks, Machine to Machine communications, Connected Vehicles, Industrial IoT. Introduction to Shape memory alloy, Piezoelectric and Magnetostrictive actuators. Introduction to Re-shaping supply chain management through a public, direct peer-to-peer (P2P) manufacturing ecosystem, Incentivizing Change in Supply Chain Management, Smart Manufacturing Blockchain, Smart Contracts for Transparent	8	1, 3, 5		

		Procurement Processing, Smart Business Model for Decentralized Supply Chain Management				
	Assignment topics	Manufacturing Utility Token: Incentivizing Blockchain Buy-in, Risk Factors. Materials static and dynamic characteristics.				
Module 4: **Recent Developments in Thermo-Fluid and Design**	In class	Introduction to thermo-fluid, micro fluids, lubrication theory, thin film dynamics, introduction to Nano fluids and Nano fluidic energy conversion. Introduction to Principle, design and performance of solar energy thermal system, some passive architecture structures. Introduction to Engineering design considering FEM.	6	2		
	Assignment topics	solar ponds, solar cooker, solar green house				
Module 5: **Hyperloop Transportation**	In class	Introduction to Capsule, Geometry, Interior, Compressor, Suspension, Onboard Power, Propulsion. Tube- Geometry, construction, pylons and tunnels, Propulsion- Rotor, Stator, Introduction to Onboard passenger Emergency, Power outage, Capsule Depressurization, Capsule Stranded in Tube, Structural Integrity of tube in Jeopardy, Earthquakes, Reliability. Economic Considerations.	6	4		
	Assignment topics	Energy Storage Components, Prolusion for Passenger plus Vehicle system. Safety and Reliability				

Textbooks:

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press).
2. Rapid Prototyping: Principles and Applications (3rd Edition) by Chee Kai Chua, Kah Fai Leong and Chu Sing Lim, (World Scientific publisher)
3. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press).

Reference Books:

1. NPTEL Lecture Series and Coursera.
2. Decentralized Manufacturing: Smart MFG Tech LTD, V16 - February 15, 2018.

Sub Code: **ME305A3** **Credit: 3 (L-3, T-0, P-0)**

COMPUTER INTEGRATED MANUFACTURING

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To describe the fundamental concepts of CIM.
2. To explain enterprise wide integration of CIM and concept of CIM wheel.
3. To differentiate between CAM, CAD/CAM, and CIM.
4. To know the scope of CIM.
5. To discuss operations flow within CAD/CAM.
6. To know the different approaches for integration of CAD/CAM.

Pre-requisites: Basic concept of CAD/CAM.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	Identify the main elements in computer integrated manufacturing systems.
CO2	Apply knowledge of computer aided process planning, feature and group technology.
CO3	Apply knowledge of data exchange in manufacturing processes.
CO4	Apply the concepts/components of computer integrated manufacturing and integrate them in a coordinated fashion.
CO5	Process product models with CAM tools and CNC machines.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction**	In class	Brief introduction to CAD and CAM - Manufacturing Planning, Manufacturing control - Introduction to CAD/CAM – Concurrent Engineering - CIM concepts - Computerised elements of CIM system – Types of production - Manufacturing models and Metrics - Simple problems - Manufacturing Control - Levels of Automation - Lean Production and Just-In-Time Production.	8	1, 2, 3, 4, 5		
	Assignment topics	Differences.				
Module 2: **Production planning and control and computerized process planning**	In class	Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- Control Systems-Shop Floor Control - Inventory Control –	8	1, 2, 3, 4, 5		
	Assignment topics	Comparison.				
Module 3: **Cellular manufacturing**	In class	Group Technology(GT), Part Families - Parts Classification and coding - Simple Problems in OpitzPart Coding system - Production flow Analysis - Cellular Manufacturing - Composite part concept - Machine cell design and layout - Arranging Machines in a GT cell - Hollier Method.	7	1, 2, 3, 4, 5		
	Assignment topics	Simple Problems.				

Module 4: **Flexible manufacturing system (FMS) and automated guided vehicle system (AGVS)**	In class	Automated Guided Vehicle System(AGVS) - AGVS Application - Vehicle Guidance technology - Vehicle Management & Safety.	6	1, 2, 3, 4, 5		
	Assignment topics	Application.				
Module 5: **Industrial robotics**	In class	Robot Anatomy and Related Attributes - Classification of Robots - Robot Control systems – End Effectors - Sensors in Robotics - Robot Accuracy and Repeatability.	7	1, 2, 3, 4, 5		
	Assignment topics	Industrial Robot Applications.				

Text Books:

1. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2008.
2. Radhakrishnan P, SubramanyanS.and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.

Reference Books:

1. Kant Vajpayee S, "Principles of Computer Integrated Manufacturing", Prentice Hall India, 2003.
2. Gideon Halevi and Roland Weill, "Principles of Process Planning – A Logical Approach" Chapman & Hall, London, 1995.
3. P Rao, N Tewari&T.K. Kundra, "Computer Aided Manufacturing", Tata McGraw Hill Publishing Company, 2000.

Sub Code: **ME306A3** **Credit: 3 (L-3, T-0, P-0)**

COMPUTER AIDED DESIGN AND MANUFACTURING

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To gain a good working understanding of Geometric Dimensioning and Tolerance.
2. To gain an understanding and appreciation of modern industrial design.
3. To be able to use a modern CAM system.
4. To understand Robotics, Automation and Rapid Prototyping.

Pre-requisites: Concept of Mechatronics, Degree of Freedom and Manufacturing.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Design parts in a modern parametric CAD system for manufacture on a rapid prototyping machine and/or a CNC machining system.
CO2	Use geometric dimensioning and tolerance based on the ASME standard in design.
CO3	Generate proper engineering drawings.
CO4	Understand function, capabilities, and limitations of modern CNC machining centers.
CO5	Understand different types of techniques used in Cellular Manufacturing and FMS.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Fundamentals of CAD/CAM**	In class	Definitions of CAD/CAM tools, product cycle and CAD/CAM, industrial utilization of CAD/CAM systems, design process and applications of computer for design, creating the manufacturing database, benefits of CAD. CAD/CAM Hardware: Types of CAD/CAM systems, system considerations, input output devices. CAD/CAM software: Introduction to CAD/CAM software, functions of a graphics package, geometry construction, transformations.	7	1,2,3		
	Assignment topics	Relationship between CAD and other software / hardware used in manufacturing.				
Module 2: **Geometric modeling**	In class	Wire frame, surface and solid modeling, mathematical representation of curves, parametric design of various curves, mathematical representation of surfaces, and parametric design of surfaces.	7	1,2,3		
	Assignment topics	Functions.				
Module 3: **Numerical Control**	In class	Need for N/C machine tools, Basic Components of N/C system, Design Consideration of N/C Machine tools, N/C motion control system, N/C coordinate systems, Preparatory Functions and Miscellaneous Functions, Examples of part programming with CNC Lathe and Milling Machine.	8	3,4		
	Assignment topics	Part Program.				
Module 4: **Basic Mechatronics and Drives Robotics**	In class	Basic concept and elements of Microprocessor, Microcomputer and Assembly Languages. Concept of Hydraulic System, Stepping Motor. Computer–Process Interfacing: Manufacturing	8	4		

		process data, System Interface hardware Devices-Transducer, Sensors. Introduction to robotics, robot physical configurations, basic robot motions, robot programming methods, robot programming languages, end effectors, work cell control and interlocks, various applications of robots.				
	Assignment topics	Upcoming Technologies.				
Module 5: **Cellular Manufacturing and Flexible Manufacturing System (FMS)**	In class	Group Technology(GT), Part Families–Parts Classification and coding–Simple Problems in Opitz Part Coding system–Production flow Analysis–Cellular Manufacturing – Composite part concept – Types of Flexibility – FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS	6	5		
	Assignment topics	Numerical.				

Text books:

1. Zimmer & Groover: CAD/CAM Computer Aided Design and Manufacture, Prentice Hall of India Pvt. Ltd., New Delhi..
2. Ibrahim Zeid: CAD/CAM, Theory & Practice, TMH.
3. Yorem Koren: Computer Control of Manufacturing Systems, McGraw Hill Book Company.
4. T.R.Chandrupatla & A.D. Belegundu: Introduction to Finite Elements in Engineering, PHI.

Reference books:

1. Mikell P. Groover: Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India Pvt. Ltd.
2. Radhakrishnan, Subramanyun & Raju: CAD/CAM/CIM, New age international.
3. Robert J Schilling: Fundamentals of Robotics-Analysis & Control, PHI.
4. Tsemeo Yoshikawa: Fundamentals o f R o b o t i c s -Analysis & Control, PHI.
5. Klaus-Surgen Bathe: Finite Element Procedures, PHI.
6. Steven M. Lepi: Practical Guide to Finite Element, Marcel Dekker Inc.

Sub Code: **ME307A3** **Credit: 4 (L-3, T-1, P-0)**

TURBO MACHINERY

Questions to be set: 05 (All Compulsory)

Course Objective: Understand the governing equations and performance of turbines and pumps. Demonstrate an ability to identify, formulate and solve complicated engineering problems related with hydraulic turbo machinery and thermal power turbo machinery.

Pre-requisites: Basics of Thermodynamics and Fluid Mechanics

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Model studies and thermodynamics analysis of turbomachines.
CO2	Investigate the energy transfer in Turbo machine with degree of reaction and utilisation factor.
CO3	Conduct performance investigation of various type of steam turbines.
CO4	Conduct performance investigation of various type of hydraulic turbine.
CO5	Conduct performance investigation of various type of centrifugal pumps

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	**Introduction:** Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Unit and specific quantities, model studies and its numerical. **Thermodynamics of fluid flow:** Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process. Simple Numerical onstage efficiency and polytropic efficiency.	8	1		
	Assignment topics	Numerical Problems related to efficiencies of turbo machines				
Module 2: **Energy exchange in Turbo machines**	In class	**Energy exchange in Turbo machines:** Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems. **General Analysis of Turbo machines:** Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance,, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles	7	2		
	Assignment topics	Numerical Problems related to degree of reaction				
Module 3: **Steam Turbines**	In class	**Steam Turbines:** Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-	8	3		

		stage impulse turbine, expression for maximum utilization factor, Numerical Problems. **Reaction turbine** – Parsons's turbine, condition for maximum utilization factor, reaction staging. Numerical Problems				
	Assignment topics	Numerical Problems related to multi-stage turbines				
Module 4: **Hydraulic Turbines**	In class	**Hydraulic Turbines:** Classification, various efficiencies. **Francis turbine** – Principle of working, velocity triangles, design parameters, **Kaplan turbines** - Principle of working, velocity triangles, design parameters, Theory and types of Draft tubes.	7	4		
	Assignment topics	Numerical Problems related to Francis and Kaplan Turbines.				
Module 5: **Centrifugal Pumps**	In class	**Centrifugal Pumps:** Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Theoretical head – capacity relationship, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.	6	5		
	Assignment topics	Numerical Problems related to Centrifugal Pumps				

Text books:

1. An Introduction to Energy Conversion, Volume III, Turbo machinery V. Kadambi and Manohar Prasad New Age International Publishers reprint 2008.
2. Turbo Machines B.U.Pai Wiley India Pvt, Ltd 1st Edition.
3. Turbo machines M. S. Govinde Gowda and A. M. Nagaraj M. M. Publications 7Th Ed, 2012.
4. Fundamentals of Turbo Machinery B.K Venkanna PHI Publishers.

Reference Books

1. Turbines, Compressors & Fans S. M. Yahya Tata McGraw Hill Co. Ltd 2nd edition, 2002.
2. Principals of Turbo machines D. G. Shepherd The Macmillan Company 1964.
3. Fluid Mechanics & Thermodynamics of Turbo machines S. L. Dixon Elsevier 2005.

Sub Code: **ME308A3** **Credit: 4 (L-3, T-1, P-0)**

COMPUTATIONAL FLUID DYNAMICS

Questions to be set: 05 (All Compulsory)

Course Objective: To provide brief introduction of Computational Fluid Dynamics along with application to analysis of fluid mechanics and heat transfer related problems.

Pre-requisites: Basics of Thermodynamics, Heat Transfer, Partial Differential Equations and Fluid Mechanics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Develop partial differential equations for equations of momentum, energy and mass.
CO2	Investigating fluid flow and heat transfer problems taking turbulence into account.
CO3	Investigate steady flow problems with finite volume method.
CO4	Deduce solutions for pressure velocity couplings using finite volume methods.
CO5	Deduce solutions for real life unsteady flow problems using finite volume methods.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Conservation Laws of Fluid Motion and Boundary Conditions**	In class	Introduction to CFD, its application , Problem solving with CFD , Governing equations of fluid flow and heat transfer, Mass conservation in three dimensions, Rates of change following a fluid particle and for a fluid element, Momentum equation in three dimensions, Energy equation in three dimensions, Equations of state, Navier–Stokes equations for a Newtonian fluid, Conservative form of the governing equations of fluid flow, Differential and integral forms of the general transport equations, Classification of physical behaviours, The role of characteristics in hyperbolic equations, Classification method for simple PDEs, Classification of fluid flow equations.	8	1		
	Assignment topics					
Module 2: **Turbulence and its modelling**	In class	Definition for turbulence. Transition from laminar to turbulent flow. Descriptors of turbulent flow. Characteristics of simple turbulent flows. Free turbulent flows. Flat plate boundary layer and pipe flow. The effect of turbulent fluctuations on properties of the mean flow. Turbulent flow calculations. Reynolds-averaged Navier–Stokes equations and classical turbulence models: Mixing length model, The k–ε model, Reynolds stress equation models, Advanced turbulence models, RANS turbulence models, Large eddy simulation	7	2		
	Assignment topics	Problem Solving				
Module 3: **The finite volume model for convection**	In class	Introduction, Finite volume method for one-dimensional steady state diffusion, Worked examples: one-dimensional steady state diffusion, Finite volume method for two-dimensional diffusion problems, Finite volume method for three-dimensional diffusion problems, Introduction: Steady one-dimensional	7	3		

and diffusion problems		convection and diffusion, The central differencing scheme, Properties of discretisation schemes, Conservativeness, Boundedness,, Transportiveness, Assessment of the central differencing scheme for convection– diffusion problems, The upwind differencing scheme, The hybrid differencing scheme: the QUICK scheme and TVD scheme				
	Assignment topics	Problems				
Module 4: **Solution algorithms of pressure-velocity coupling and discretised equations**	In class	Introduction, The staggered grid, The SIMPLE algorithm, Assembly of a complete method, The SIMPLER algorithm, The SIMPLEC algorithm, he PISO algorithm, General comments on SIMPLE, SIMPLER, SIMPLEC and PISO, TDMA	7	4		
	Assignment topics	Problems				
Module 5: **The finite volume method for unsteady flows**	In class	Application of the TDMA to two-dimensional and three-dimensional problems, One-dimensional unsteady heat conduction, Explicit scheme, Crank–Nicolson scheme, The fully implicit scheme, llustrative examples, Implicit method for two- and three-dimensional problems, Discretisation of transient convection–diffusion equation	7	5		
	Assignment topics	Numerical Problems				

Text Books:

1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill (1998).
2. Muralidhar K. and Sundararajan, T. Computational Fluid Flow and Heat Transfer, Narosa Publishing. House (1995).

Reference Books:

1. H Versteeg and Malasakara, Introduction to computational fluid dynamics, Pearson education (2006).
2. LI J., G. H. Yeoh, C Liu. A Computational Fluid Dynamics, ELSEVER (2008)
3. Suhas V. Patankar. Numerical Heat Transfer and Fluid Flow, Taylor and Francis (1978).
4. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills (1995).

Sub Code: **ME309A3** **Credit: 4 (L-3, T-1, P-0)**

OPERATIONS RESEARCH

Questions to be set: 05 (All Compulsory)

Course Objective: This course aims to introduce students to use quantitative methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Pre-requisites: Concept of principal of management and industrial engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Analyze any real life system with limited constraints and depict it in a model form, convert the problem into a mathematical model and use suitable method to find the solution.
CO2	Build and solve Transportation Models and Assignment Models.
CO3	Develop mathematical skills to analyze and solve network models arising from a wide range of applications.
CO4	Formulate Queuing models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these Queuing problems.
CO5	Understand the basics of game theory and application of operations research to such problems.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Linear Programming**	In class	Definition, phases, application of O.R., assumptions in L.P.P., formulation, graphical solution, simplex method (technique and algorithm).	8	1		
	Assignment Topics	Problems solving				
Module 2: **Transportation and Assignment model**	In class	**Transportation model:** Algorithm for Transportation problems, NWC, Least cost, VAM, MODI method. **Assignment model:** Definition, solution algorithm for assignment models (Hungarian method).	7	2		
	Assignment Topics	Problems solving				
Module 3: **Networks**	In class	CPM and PERT analysis. General Explanation, Calculation of event times, activity times, total float, free float, independent float.	7	3		
	Assignment Topics	Problems solving				
Module 4: **Queuing models**	In class	Queuing systems and structures, Notation parameter, Single server and multi-server models, Poisson input, Exponential service, Constant rate service, Infinite population problem	7	4		
	Assignment Topics	Problems solving				
Module 5: **Game Theory**	In class	Game Theory: Introduction, Characteristics of Game Theory, Two Person Zero sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, mx2).	7	5		
	Assignment Topics	Problems solving				

Text Books:

1. Hamdy A. Taha: Operations Research, PHI.
2. Prem Kr Gupta and D. S. Hira: Operations Research.
3. N. D. Vohra: Operation Research, TMH.

Reference Books:

1. S. D. Sharma: Operations Research, Kedar Nath and Ram Nath &Co.
2. P. C. Tulsian and V. Pandey: Quatitative Techniques- Theory and Problems, Pearson Education.
3. Lovin and Krit Patrick: Quantitative approach to Management, TMH.

Sub Code: **ME310A3** **Credit:4 (L-3, T-1, P-0)**

REFRIGERATION AND AIR CONDITIONING

Questions to be set: 05 (All Compulsory)

Course Objective:

1. Students will learn the basic concepts and principles of air conditioning and refrigeration.
2. Students will learn the fundamental analysis methodology of air conditioning and refrigeration.
3. Students will learn the basic process and systems of air conditioning and refrigeration.

Pre-requisites: Basics knowledge of Thermodynamics, Fluid Mechanics.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	To analyze the refrigeration systems used for domestic and industrial applications.
CO2	To evaluate a simple air conditioning system used for various applications.
CO3	To analyze psychometric processes and cycles of air conditioning systems.
CO4	To calculate the energy requirements for cooling and heating process.
CO5	To estimate the requirement of refrigeration and air conditioning applications.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Gas cycle refrigeration**	In class	Reversed Brayton Cycle, Application in Air–Craft Refrigeration- Simple system, Bootstrap system, Regenerative system, Reduced Ambient system.	6	1,2		
	Assignment topics	Numerical Questions				
Module 2: **Vapour compression refrigeration**	In class	VCRs; Multi-stage or compound system-Flash gas removal, flash inter-cooling, complete multi-stage compression system; Multi-evaporator system; Cascade system. Refrigeration & Air-conditioning Devices: compressor, evaporators, condenser and Expansion device.	8	1,2		
	Assignment topics	Numerical Questions				
Module 3: **Vapour absorption system**	In class	Simple VAR system, Modification of simple VAR system, Maximum co-efficient system.	6	1,2		
	Assignment topics	Numerical Questions				
Module 4: **Psycrometries and Air conditioning**	In class	Properties of moist air, mixing process, By- pass factor, Sensible heat factor, Basic processes in Air-conditioning, Air-washer, Psychrometric chart. Summer and winter Air conditioning.	8	3		
	Assignment topics	Numerical Questions				
Module 5: **Load calculation**	In class	Internal heat gain, System heat gain, Effective sensible heat factor, Cooling & heating load estimation.	8	4,5		
	Assignment topics	Numerical Questions				

Text books:

1. P. K. Nag: Engineering Thermodynamics, Tata McGraw Hill
2. R. K. Rajput: A Text Book of Engineering Thermodynamics, Laxmi Publications, New Delhi

Reference books:

1. Reinhold Co., New York, 1984. 7. Arora C.P., “Refrigeration & Air Conditioning”, Tata Mc Graw Hill, 1985.
2. Jones W.P., “Air Conditioning Engineering”, Edward Arnold Publishers Ltd., London, 1984.
3. Sontag, Borgnakke and Van Wylen: Fundamentals of Thermodynamics, John Wiley
4. C P Arora: “Refrigeration & Air Conditioning”, Tata McGraw
5. ASHRAE Handbook “Handbook of air-conditioning system design”, Carrier Incorporation, McGraw Hill Book Co.

Sub Code: **ME311A3** **Credit: 4 (L-3, T-1, P-0)**

FINITE ELEMENT METHOD

Questions to be set: 05 (All Compulsory)

Course Objective: Finite element method will help the students:

1. To learn basic principles of finite element analysis procedure.
2. To learn the theory and characteristics of finite elements that represent engineering structures.
3. To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Pre-requisites: Basics of mechanical engineering and engineering mathematics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Interpret the philosophy behind principles, design and modelling considerations in using finite element analysis.
CO2	Develop the finite element formulations for heat transfer problems.
CO3	Develop stiffness matrices for spring, truss, beam, plane stress problems
CO4	Solve one dimensional problems using the concept of direct equilibrium and potential energy methods.
CO5	Solve multidimensional problems using the concept of direct equilibrium and potential energy methods.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction of FEM**	In class	Introduction, historical background, applications, advantages, finite element software.	7	1		
	Assignment topics	numerical				
Module 2: **Discretization methods**	In class	Theory of elasticity - stress and equilibrium, stress-strain relationship, strain-displacement, relationship, plane stress, plane strain and axi-symmetric approximation. Temperature effects.	7	2		
	Assignment topics	Axi-symmetric approximation and Temperature effects.				
Module 3: **Problem formularization methods**	In class	Potential energy and equilibrium, Principle of minimum potential energy. Discrete and Continuous systems, Rayleigh-Ritz method, Galarkin method. Solution of Algebraic equations, Banded and skyline solutions. Global, Local and Natural coordinates in 1, 2 and 3 dimensions - Area coordinates. Numerical Integration using Gauss quadrature. Finite element modeling - types of elements, Discretization, Mesh generation and numbering. Shape functions - types and properties.	8	3		
	Assignment topics	Mesh generation and numbering. Shape functions - types and properties.				
Module 4: **One Dimensional**	In class	One dimensional elasticity problems - discretization of domain into elements – generalized coordinates approach - derivation of elements equations - assembly of element equations - transformation	7	4		

problem handling		matrices - global equations, load vector, properties of stiffness matrices, imposition of Boundary conditions - penalty and elimination approach, multi-point constraints. Finite element formulation of plane trusses, beams and beams on elastic supports.				
	Assignment topics	Global equations, load vector, properties of stiffness matrices				
Module 5: **Two Dimensional problem handling**	In class	Finite element formulation of 2D problems using constant strain triangle element and isoperimetric quadrilateral element. Axi-symmetric solids subjected to axi-symmetric loading.	7	5		
	Assignment topics	Axi-symmetric solids subjected to axi-symmetric loading				

Test books:

1. Reddy: An Introduction to Finite Element Method: McGraw-Hill, 3/e.
2. Hutton: Fundamentals of Finite Element Analysis: McGraw-Hill, 1/e.
3. Krishnamoorthy: Finite Element Analysis: Theory and Programming: McGraw-Hill, 2/e.

Reference books:

1. T. K. Chandrupatla and A. D. Belegundu: Introduction to Finite Elements In Engineering: Prentice Hall of India Pvt. Ltd., New Delhi.
2. S. Rajasekaran: Finite Element Analysis in Engineering Design: Wheeler Publishing.
3. K. S. Bathe & E. L. Wilson: Finite Element Method: Prentice Hall of India.
4. R. D. Cook: Concepts and Applications of Finite Element Analysis.

Sub Code: **ME312A3** **Credit: 4 (L-3, T-1, P-0)**

MECHANICAL VIBRATION

Questions to be set: 05 (All Compulsory)

Course Objective: Vibrations is an inter-disciplinary field that should be explored by physics, medicine, mechanical engineering, and mathematics professionals. Upon completion of this course, the student should be able to:

1. To use Newton's second law or energy concepts to develop mathematical models for vibrational problems.
2. To determine a complete solution of mechanical vibration problems using various mathematical or numerical techniques.
3. To determine physical and design interpretations from the results.
4. To apply skills and understanding, and be able to solve standard vibration problems that occur in mechanical engineering applications

Pre-requisites: Knowledge of Strength of Materials, Engineering Mechanics, Theory of Machine, Engineering Mathematics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Establish equation of motion and calculate the natural frequency of freely vibrating SDOF undamped and damped systems.
CO2	Analyse any periodic function into a series of simple harmonic motions using Fourier series analysis.
CO3	Implement the complete solution for the motion of a SDOF vibratory system that is subjected to forcing functions.
CO4	Implement the complete solution for the motion of a 2-Degree vibratory system that is subjected to free and forcing functions.
CO5	Analyse the use of vibration measuring devices and solve vibration problems that contain multiple degrees of freedom

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Undamped free vibration of SDOF systems :**	In class	Equations of motion, Newton's law, D'Alembert's Principle and Energy method; expressions for natural frequency of various spring-mass, torsional and other systems with different types of restoring forces.	8	1		
	Assignment topics	Some definition and terminology, simple harmonic motion.				
Module 2: **Damped free vibration of SDOF systems**	In class	Viscous damping; response of overdamped, critically damped and underdamped systems – logarithmic decrement; response of systems with Coulomb damping	8	2		
	Assignment topics	Few problem solving				
Module 3: **Forced vibration of SDOF systems, Vibration measuring instruments:**	In class	Steady state forced vibration due to external harmonic force, rotating and reciprocating unbalance; vibration isolation and transmissibility; determination of equivalent viscous damping from frequency response curve, Seismic type; Displacement measuring instrument - vibrometer, and accelerometers	8	3		
	Assignment topics	Properties of base excitation, velocity pick-up instruments				

Module 4: **Free and Forced vibration of two DOF systems**	In class	Equations of motion for different undamped systems; natural frequency and normal modes of vibration. Undamped forced vibration with harmonic excitation; undamped dynamic vibration absorber.	6	4		
	Assignment topics	centrifugal pendulum absorber, Problems on undamped dynamic vibration absorber,				
Module 5: **Vibration of multi DOF systems, Whirling of shaft**	In class	Equations of motion in matrix form, influence coefficients, mass, flexibility and stiffness matrices; determination of natural frequency and mode shape by Holzer method and matrix iteration method. Critical speed of a light shaft – without and with damping.	6	5		
	Assignment topics	Determination of natural frequency by Dunkerley's and Rayleigh's methods; determination of natural frequency and mode shape by Holzer method				

Text Books:

1. G.K. Grover: Mechanical Vibrations, Nem Chand & Bros., Roorkee.
2. W.T. Thomson: Theory of Vibration with Applications, CBS Publishers, New Delhi.
3. S.S. Rao: Mechanical Vibrations, Pearson Education, Delhi.

Reference Books:

1. Tse, Morse and Hinkle: Mechanical Vibrations, CBS Publishers, New Delhi.
2. Timoshenko: Vibration Problems in Engineering.

Sub Code: **ME313A3** **Credit: 4 (L-3, T-1, P-0)**

PRODUCTION AND OPERATIONS MANAGEMENT

Questions to be set: 05 (All Compulsory)

Course Objective: This course aims at teaching the students to look at the production planning and inventory control systems through a managerial perspective; obtaining a fair understanding of how operations managers allocate the resources using long term capacity planning, aggregate production planning, and inventory analysis; recognizing the relationships among the strategic, tactical and operational levels of planning in production systems; and gaining expertise in production and inventory control tools.

Pre-requisites: Basics of Industrial Management.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Identify and use codes used in industries, differentiate between products and services
CO2	Utilize the suitable forecasting technique according to predict future product demand in industries and businesses
CO3	Prepare Bill of Materials (BOM) and MRP Sheets in industries and businesses.
CO4	Prepare efficient schedules for industrial manufacturing processes and operations.
CO5	Identify plant/ industrial locations based on opportunities and constraints and design suitable plant layout according to situation.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to Operations Management**	In class	Basic Concept and Historical Development of Operations Management; Current Trends and Issues in Operations Management.	5	1		
	Assignment topics					
Module 2: **Forecasting**	In class	Demand Management; Types of Forecasting – Long and Short-term demand forecasting methods; Components of Demand; Time Series Analysis – Simple Moving Average, Weighted Moving Average, Exponential Smoothing, Forecast Errors, Sources of Error, Measurement of Error, Linear Regression Analysis, and Decomposition of a Time Series	7	2		
	Assignment topics	Numericals Related to Forecasting				
Module 3: **Aggregate Production Planning and Resource Planning**	In class	Productivity Definitions, Scope and measurement; Productivity improvement methods for organizations in India; Framework of Aggregate Production Planning; Basic Strategies – Level Strategy, Chase Strategy, and Mixed Strategy; Master Production Scheduling; Resource Planning – Multiple Levels in Product, Product Structure, Bill of Materials (BOM); Material Requirement Planning (MRP); Capacity Requirements Planning (CRP); Manufacturing Resource Planning (MRP-II).	7	3		
	Assignment topics	Numericals related to MRP				
Module 4:	In class	Loading of Machines – Assignment Rule (Hungarian Method); Priority Rules and Techniques for Job Shop	8	4		

Scheduling of Operations		and Flow Shop Scheduling, Shortest Processing Time (SPT), Longest Processing Time (LPT), Earliest Due Date (EDD),Critical Ratio (CR); Johnson's Rule and Gantt Chart – Scheduling of 'n' Jobs on Two Machines, 'n' Jobs on Three Machines, 'n' Jobs on 'k' Machines, and 2 Jobs on 'k' Machines.				
	Assignment topics	Numericals Related to Scheduling				
Module 5: **Plant Location and Plant Layout**	In class	Importance of Plant Location; Factors Affecting Plant Location; Quantitative Methods for Plant Location – Centre of Gravity Method, Load-Distance Method, and Transportation Model; Definition of Plant Layout; Objectives and Importance of Plant Layout; Muther's Principle of Plant Layout; Types of Plant Layouts – Product, Process, Combination, and Fixed Position Layouts; Quantitative Techniques for Planning Layouts – Flow Process Charts, Activity Relationship Charts, Travel Chart, Load-Distance Matrix Method, Line Balancing – Basic concept, Line Balancing Methods (Kilbridge Method and Rank Positional Weight Method), and Concepts of Balance Delay and Balance Efficiency	8	5		
	Assignment topics	Numericals related to plant layout				

Text Books:

1. Richar B Chase, F Robert Jacobs, Nicholas J Aquilano, and Nitin K Agarwal: Operations Management for Competitive Advantage, McGraw-Hill.
2. N. D. Vohra; Quantitative Techniques in Management, McGraw Hill Education.

Reference Books:

1. J Krajewski and Larry P Ritzman: Operations Management – Strategy and Analysis, Prentice Hall.
2. Sang M Lee and Marc J Schniederjans;Operations Management, oughton Mifflin College Div.

Sub Code: **ME314A3** **Credit: 4 (L-3, T-1, P-0)**

POWER PLANT ENGINEERING

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To develop a basic concept of different power plant.
2. To familiar with different components used in power plant.
3. To able to implement their theoretical knowledge in their practical power plants.

Pre-requisites: Basics knowledge of Thermodynamics, Fluid Mechanics

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	To analyze and evaluate the performance of single & combined Rankine cycle & efficiency enhancement.
CO2	To analyze and evaluate the performance of gas turbine power plant.
CO3	To analyze and evaluate the performance of hydroelectric power plant.
CO4	To analyze and evaluate the performance of nuclear power plant.
CO5	To develop the concept of different renewable energy sources and energy conversion techniques.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Thermal Power Plant**	In class	Plant layout, Rankine cycle, Components: Boiler & Auxiliaries , Turbine & Auxiliaries, Steam Condensers and Cooling Tower, Selection of site, Fuel used-Coal, Classification of coal, Analysis of coal, Coal handling system, Ash handling system, Equipment used for preparation & burning of Pulverized coal.	8	1		
	Assignment topics	Burning of Pulverized coal				
Module 2: **Gas Turbine Plant**	In class	Plant layout, Brayton cycle, Methods to improve the efficiency of the gas turbine plant, Combined cycle power plant.	6	2		
	Assignment topics	Numerical Questions				
Module 3: **Hydro-electric Power Plant**	In class	Selection of site, Plant layout, Hydrology, Essential Equipments-Surge tank, Penstock, Spillways, Gates and Valves, Power house, Draft tube	6	3		
	Assignment topics	Draft tube				
Module 4: **Nuclear Power Plant**	In class	Selection of site, Principle of release of nuclear energy, Fission & Fusion reaction, Fuels used, Main parts of a reactor & their function, Coolant cycle, Plant layout. Emissions from power plants and their controls.	6	4		
	Assignment topics	Numerical Questions				
Module 5: **Renewable energy Power plant**	In class	Solar power plant: Types, working principles, solar energy technologies, Wind Energy power plant: Principle of wind energy conversion, Geothermal energy power plant, Ocean Energy power plant: Introduction, Principle	10	5		

		of ocean thermal energy conversion (OTEC), Tidal power generation, Tidal energy technologies, Bio-Energy: Sources of biomass, Conversion of biomass into fuel, technologies.				
	Assignment topics	Conversion of biomass into fuel, technologies.				

Text books:

1. P. K. Nag : Power Plant Engineering, TMH
2. Domkundawar: Power Plant Engineering, Dhanpat Rai & Sons.

Reference Books:

1. A. Chakrabarty, M. L. Soni, P. V. Gupta, U. S. Bhatnagar: Power System Engineering, Dhanpat Rai & Sons.
2. S. C. Bhatia, R. K. Gupta: Textbook of Renewable Energy (Woodhead Publishing India in Energy)

ME315A3 **Credit: 4 (L-3, T-1, P-0)**

MACHINE LEARNING

Questions to be set: 05 (All Compulsory)

Course objectives: The course will enable the students to

1. Building the fundamentals of Machine Learning
2. imparting Statistical and linear algebra skills for Machine learning
3. Developing neural network models for engineering applications
4. Gaining practical experience in programming tools for Machine Learning
5. Empowering students with tools and techniques used in Machine Learning

Pre-requisites: Concept of mathematics.

Course outcomes (CO): On Successful Completion of the course students will able to:

CO	Statement
CO1	Identify the importance and applications of machine learning and apply linear algebra methods to model engineering data
CO2	Understand various supervised and unsupervised ML algorithms
CO3	Apply dimension reduction technique to reduce the dimensions of the data
CO4	Apply and analyze different machine learning tools and techniques
CO5	Design and implement various machine learning algorithms for real-world applications

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Basics of linear algebra**	In class	Review linear algebra, vector spaces, Linear transformations, Eigen values and vectors, random variables, and probability distributions. Introduction to signal processing – Time, Frequency, Time Frequency domain analysis. Regression – Simple and regularized Linear Regression, Gradient descent, Multiple linear regression in multiple variables – Linear models for classification, Discriminant functions, Logistic regression	10	1	1, 2, 3, 4, 10, 11	2
	Assignment Topics					
Module 2: **Supervised and unsupervised ML algorithms**	In class	Basic motivation, examples of machine learning applications Unsupervised, Supervised, Reinforcement, Hybrid models, Handling datasets, Performance metrics	8	2	1, 2, 3, 4, 10, 11, 12	2
	Assignment Topics					
Module 3: **Dimension reduction technique**	In class	Dimensionality reduction - Principal Component Analysis, Singular Value decomposition, Fundamentals of Deep Learning and Reinforcement Learning.	10	3	1, 2, 3, 4, 10, 11, 12	2
	Assignment Topics					
Module 4: **Machine learning tools**	In class	Classification - Decision Tree, Support Vector Machine, Naïve Bayes, Neural networks model representation-Feed-forward network functions, Network training, Back-propagation algorithm.	10	4	1, 2, 3, 4, 10, 11, 12	2

		Clustering, Mixture densities, K-Means clustering, Expectation maximization, Spectral clustering.				
	Assignment Topics	Examples				
Module 5: **Application of machine learning**	In class	Application of machine learning in mechanical design, case studies in dynamics, fault analysis, system control, modeling, etc.	10	5	1, 2, 3, 4, 10, 11, 12	2
	Assignment Topics	Examples				

Text Books:

1. **T. Hastie, R. Tibshirani, J. Friedman**. The Elements of Statistical Learning, 2008.
2. **Christopher Bishop**. Pattern Recognition and Machine Learning.

Reference Books:

1. **E. Alpaydin**, Introduction to Machine Learning, 3rd Edition, Prentice Hall (India) 2015.
2. **R. O. Duda, P. E. Hart, and D. G. Stork**, Pattern Classification, 2nd Edn., Wiley India, 2007.
3. **C. M. Bishop**, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer, 2006.
4. **S. O. Haykin**, Neural Networks, and Learning Machines, 3rd Edition, Pearson Education (India), 2016

MECHANICAL ENGINEERING (OPEN ELECTIVES)

Sub Code: **ME201A2** **Credit: 4 (L-3, T-1, P-0)**

RENEWABLE ENERGY

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able:

1. To understand the fundamentals of different renewable energy resources.
2. To identify the new methodologies/technologies for effective utilization of these resources into useful work.
3. To recognize the importance of energy conservation and understand the various principles of energy conservation.
4. To understand the importance of back up storage devices

Pre-requisites: None.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Comprehend the need, importance and scope of non-conventional and renewable energy sources and apply the concepts and laws of energy and basic sciences while modeling and evaluating performances of renewable energy sources
CO2	Model and evaluate techno-economic performances of various renewable energy conversion systems related to solar and wind energy.
CO3	Model and evaluate techno-economic performances of various renewable energy conversion systems related to geothermal, ocean and hydro energy.
CO4	To compare various biofuels based on their production processes and performance on systems.
CO5	Manage energy utilization from the user and supply side and model back-up systems.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Review of basic topics in the context of Energy, Forms of Energy, Classification of Renewable Energy, Difference between Renewable and Sustainable Energy, Energy Scenario in the World, Energy from production to end-use, Issues with conventional energy.	5	1		
	Assignment topics	Numerical Problems related to energy production to end-use				
Module 2: **Solar and Wind Energy**	In class	Solar Radiation, Measurements of Solar Radiation, Flat Plate and Concentrating Collectors, Solar thermal applications, Solar Thermal Power Generation. Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation and PV Applications, Wind Energy Estimation, Types of Wind Energy Systems, Performance, Site Selection, Wind Turbine Power Generation, Off shore and On-Shore Wind Turbines	10	2		
	Assignment topics	Numerical Problems related to wind and solar energy				
Module 3: **Geothermal, Ocean thermal , Hydro and Hydrokinetic Energy**	In class	Resources, basics of geothermal energy conversion, types of wells, methods of harnessing the energy, scope in India Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.	7	3		
	Assignment topics	Numerical Problems related to geothermal and hydel energy				

Module 4: **Biogas, Biomass and Biofuels**	In class	Principles of Bio-Conversion, Anaerobic and aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, biodiesel and bioethanol	7	4		
	Assignment topics	Production of bioethanol or biodiesel				
Module 5: **Energy Storage Devices**	In class	Brief introduction to Battery, fuel cells. Principles of energy conservation, Fundamentals of Demand side and supply side management of energy	6	5		
	Assignment topics	Concept of pumped hydro storage				

Text Books:

1. Renewable energy resources: Tiwari and Ghosal, Narosa publication.
2. Non-conventional Energy Sources: Khanna Publication.

Reference Books:

1. Renewable Energy Sources: Twidell & Weir, CRC Press.
2. Solar Energy: S.P. Sukhatme, Tata McGraw-Hill.
3. Non-Conventional Energy Systems: K M. Mittal, A H Wheeler Publishing Co Ltd.
4. Renewable Energy Technologies: Ramesh & Kumar, Narosa publication.
5. Biomass Energy, Oxford & IBH Publication.

Sub Code: **ME202A2** **Credit: 4 (L-3, T-1, P-0)**

SUPPLY CHAIN MANAGEMENT

Questions to be set: 05 (All Compulsory)

Course Objective: To get an understanding of the various supply chain management procedures as well as their interrelationships within specific organizations. Upon completion of this course, the student should be able to:

1. To understand of the management components of supply chain management.
2. Gain an understanding of the tools and processes necessary for supply chain management implementation.

Pre-requisites: None.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the decision phases and apply competitive and supply chain strategies.
CO2	Understand individual processes and drivers of supply chain performance.
CO3	Analyze factors influencing network design.
CO4	Analyze the role of forecasting in a supply chain
CO5	Understand the role of aggregate planning, inventory, IT and coordination in a supply chain.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Strategic Framework**	In class	Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.	8	1		
	Assignment topics	Information and Material Handling,				
Module 2: **Supply Chain Drivers and Metrics**	In class	Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit. Physical distribution - Definition, Importance	7	2		
	Assignment topics	participants in physical distribution process				
Module 3: **Designing Supply Chain Network**	In class	Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation	8	3		
	Assignment topics	Channels for Consumer goods, Industrial Goods & Services				
Module 4: **Forecasting in Supply Chain**	In class	Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.	6	4		
	Assignment topics	Problems on Forecasting				
Module 5: **Aggregate Planning and Inventories in Supply Chain**	In class	Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a supply chain, Managing uncertainty in a SC: Safety Inventory. Costs associated with Inventory– Basic EOQ Model – EOQ with discounts; ABC Analysis	7	5		
	Assignment topics	Numerical on Basic EOQ, EOQ with discounts & ABC				

Text Books:

1. Sunil Chopra and Peter Meindl: 'Supply Chain Management - Strategy, Planning and Operation, 6th Edition, Pearson Education Asia, 2016.
2. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy: Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 3rd Edition, Tata-McGraw Hill, 2016.

Reference Books:

1. John J Coyle, et.al.: 'Managing Supply Chains A Logistics Approach, 9th Edition, Cengage Learning, 2013..
2. Jeremy F Shapiro: Modeling the Supply Chain, 2nd Edition, Cengage Learning, 2007.

Sub Code: **ME203A2** **Credit: 4 (L-3, T-1, P-0)**

ALTERNATIVE FUELS AND LUBRICATIONS FOR ENGINES

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To acquainted with the scope of different alternative fuels for IC engine.
2. To provide students with the knowledge on the properties, applications, limitations and different techniques of blending of different fuels
3. To acquainted with the use of lubrications and different lubricants in IC engine.

Pre-requisites: Industrial engineering, Production system.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the importance of alternative fuels.
CO2	Analyze the various parameters that are utilized to characterize alternative fuels and its suitability for SI engine
CO3	Analyze the various parameters that are utilized to characterize alternative fuels and its suitability for SI engine
CO4	Understand and analyze the theory of lubrications in IC engine.
CO5	Understand and analyze characteristics and suitability of different lubricants.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to alternative fuels**	In class	Introduction to alternative fuels, Need for alternative fuels - Availability of different alternative fuels for SI and CI engines. Properties of potential alternative fuels.	6	1		
	Assignment topics	Properties of potential alternative fuels				
Module 2: **Alternative fuels for SI Engines**	In class	Liquid Fuels for SI Engines, Different Techniques of utilizing alternative liquid fuels Blends, Neat form, Gaseous Fuels in SI Engines , Reformed fuels - Manufacturing, Storage and Safety, Performance and emission characteristics of alternative liquid fuels.	8	2		
	Assignment topics	Storage and Safety				
Module 3: **Alternative fuels for CI engines**	In class	Liquid Fuels in CI Engines, Different techniques for their utilization- Blends, Fuel modifications to suit CI engines, Dual fuelling, Ignition accelerators and other additives, Gaseous Fuels in CI Engines.	6	3		
	Assignment topics	Dual fuelling				
Module 4: **Theory of lubrication**	In class	Engine friction: introduction, total engine friction, effect of engine variables on friction, hydrodynamic lubrication, elasto hydrodynamic lubrication, boundary lubrication, bearing lubrication, functions of the lubrication system, introduction to design of a lubricating system.	8	4		
	Assignment topics	Elasto hydrodynamic lubrication				
Module 5: **Lubricants**	In class	Specific requirements for automotive lubricants, oxidation deterioration and degradation of lubricants, additives and additive mechanism, synthetic lubricants,	8	5		

		classification of lubricating oils, properties of lubricating oils, tests on lubricants. Grease, classification, properties.				
	Assignment topics	Synthetic lubricants				

Text books:

1. Ramadhas A S, “Alternative Fuels for Transportation”, CRC Press, Taylor & Francis Group, 2010.

Reference books:

1. Thipse S S, “Alternative Fuels: Concepts, Technologies and Developments”, Jaico Book Distributors, 2010.
2. Gajendra Babu M K, “Alternative Transportation Fuels: Utilization in Combustion Engines”, CRC Press, Taylor & Francis Group, 2010.
3. Michael F. Hordeski, “Alternative Fuels: The Future of Hydrogen”, The Fairmont Press, 2008.
4. James D. Halderman, “Hybrid and Alternative Fuel Vehicles”, (2e), Prentice Hall, 2010.

Sub Code: **ME204A2** **Credit: 4 (L-3, T-1, P-0)**

COMPOSITE MATERIALS

Questions to be set: 05 (All Compulsory)

Course Objective: Composite Material will help the students to:

1. To understand the mechanical behaviour of composite materials.
2. To get an overview of the methods of manufacturing composite materials.

Pre-requisites: Basic concept of Mechanical Engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	Understand the importance of Composite Materials in various application fields of engineering and specifics of mechanical behaviour of layered composites compared to isotropic materials.
CO2	Understand the various composite fabrication methods.
CO3	Understand the effect of different orientation of fibres in composites and its mechanical characteristics.
CO4	Understand the various aspect of short fibre composite.
CO5	Understand the analysis of laminated composite materials.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to Composite Materials, Fibers**	In class	Definition, characteristics, Classification. Advanced Fibers, Glass Fibers, Carbon and Graphite Fibers, Aramid Fibers.	9	1		
	Assignment topics	Glass Fibers, Carbon and Graphite Fibers, Aramid Fibers.				
Module 2: **Fabrication of Composites**	In class	Matrix Materials, Fabrication of Composites	7	2		
	Assignment topics	Different process				
Module 3: **Behavior of Unidirectional Composites**	In class	Longitudinal behavior of Unidirectional Composites, Transverse Stiffness· and Strength, Prediction of Shear Modulus, Prediction of Poisson's Ratio, Failure Modes I, Expansion Coefficients and Transport 'Properties, Typical Unidirectional Fiber Composite Properties.	7	3		
	Assignment topics					
Module 4: **Short-Fiber Composites**	In class	Theories of Stress Transfer, Modulus and Strength of Short-Fiber Composites, Ribbon-Reinforced Composites. Stress-Strain Relations and Engineering Constants, Hooke's Law and Stiffness and Compliance Matrices,	7	4		
	Assignment topics	Numericals				
Module 5: **Analysis of Laminated Composites**	In class	Strengths of an Orthotropic Lamina, Laminate Strains, Variation of Stresses in a Laminate, Resultant Forces and Moments: Synthesis of Stiffness Matrix, Laminate Description System, Construction and Properties of Special Laminates, Determination of Laminae Stresses and Strains, Analysis of Laminates after Initial Failure, Hygrothermal Stresses in Laminates.	9	5		
	Assignment topics	Numerical				

Text books:

1. Broutman, et. al.: Analysis and Performance of Fiber Composites –WILEY

Reference books:

1. Chung et. al.: Composite Materials: Science and Applications- springer
2. Jones et. Al.: Mechanics of Composite Materials, - Tylor & Francis

Sub Code: **ME205A2** **Credit: 4 (L-3, T-1, P-0)**

INTRODUCTION TO NANOTECHNOLOGY AND MEMS

Questions to be set: 05 (All Compulsory)

Course Objective: The course outlines the following objective:

1. To inspire the students to expect to the trends in development and synthesizing of nano systems and measuring systems to nano scale.
2. To expose the students to the evolution of Nano systems, to the various fabrication techniques
3. Also to impart knowledge to the students about nano materials and MEMS

Pre-requisites: Basic understanding of Material science.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	To get the basic knowledge of the evolution of Nano technology.
CO2	To impart knowledge to the students about nano materials and Nano composites
CO3	To get knowledge about various characterization techniques for the measurement of nanomaterials
CO4	To understand nano scale manufacturing
CO5	The students are expected to understand MEMS.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Nanotechnology Basics**	In class	Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration.	6	1		
	Assignment topics	surface effects on the properties of Nanomaterials, Advantages of Nanomaterials				
Module 2: **Science of Nano Materials:**	In class	Classification of nano structures - effect of the nanometer length scale effects of nano scale dimensions on various properties - structural, thermal, chemical, mechanical, magnetic, optical and electronic properties - effect of nanoscale dimensions on biological systems. Fabrication methods - Top down processes - bottom up process.	8	2, 4		
	Assignment topics					
Module 3: **Nano scale manufacturing:**	In class	Nanomanipulation, Nanolithography - An introduction to tribology and its industrial applications - Nanoscale Materials and Structure, Nanocomposites,	6	2, 4		
	Assignment topics	Application of nanocomposites				
Module 4: **Characterization of Nanomaterials**	In class	Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM), Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Nano indentation, Nano scratch, Infra-red spectroscopy (IR), Raman Spectroscopy, Photoluminescence (PL), X-ray photoelectron spectroscopy (XPS)	12	3		
	Assignment topics	Scanning Tunneling Microscopy (STM), X-ray diffraction, powder diffraction, lattice parameters,				

		structure analyses, strain analyses, phase identification, particle size analyses using - Scherer`s formula -				
Module 5: **Introduction to MEMS and Micro Systems**	In class	. MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Microfabrication, Microsystems and Microelectronics, The Multidisciplinary Nature of Microsystem, Design and Manufacture, Microsystems and Miniaturization,	6	5		
	Assignment topics	Applications of Microsystems in the Automotive Industry, Applications of Microsystems in Other Industries				

Text Books:

1. Mark Ratner & Daniel Ratner, Nano Technology, Pearson Education,2003
2. "Introduction to Nanoscience", G.L. Hornyak, J. Dutta, H.F. Tibbals, A.K. Rao, CRC Press, ISBN: 978-1-4200-4805-6.

Reference books:

1. Introduction to Nanoscience", S.M.Lindsay, Oxford ISBN 978-019-954421-9 (2010). Availableon-line from the library.

Sub Code: **ME206A2** **Credit: 4 (L-4, T-0, P-0)**

Foundations of EV & Hybrid Vehicles

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To provide the performance characteristics of electric and hybrid vehicles.
2. To explain the environmental impact and sustainability considerations associated with electric and hybrid vehicles
3. To understand the design and operation of charging infrastructure, as well as power management systems in electric and hybrid vehicles.
4. To teach the learners on how to integrate various components at the system level to ensure efficient and reliable operation of electric vehicles

Pre-requisites: Fundamentals of Maths and Science

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Apply the fundamental principles of Science and Engineering, and study the performance characteristics of electric and hybrid vehicles.
CO2	Relate the environmental impact, sustainability aspects, and policy/regulatory dynamics of electric and hybrid vehicles.
CO3	Demonstrate knowledge of Electrical power, Control System and analysis.
CO4	Demonstrate knowledge of charging infrastructure, power management systems, and emerging trends in the electric and hybrid vehicle field.
CO5	Illustrate the component level integration of Electric Vehicles.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Principles for Electric Vehicles**	In class	EV Industry, EV Technology and Automotive Revolution, Electrical Engineering for EV, Battery Technology	9	1		
	Assignment topics					
Module 2: **Control system for Electric Vehicles**	In class	Motor and Controller Systems, EV Numerical Calculations, EV Charging Infrastructure, Practical session - Well-to-wheel analysis of EV architecture	9	2,3		
	Assignment topics					
Module 3: **Essentials for Electric Vehicles**	In class	Electrical Requirement, Power Distribution Specifications, Electronic Control System, Practical session - EV connection and system analysis	9	3		
	Assignment topics					
Module 4: **Types of components in Electric Vehicles**	In class	EV Standards and Classifications, Selection for Electrical and Electronic Components, Practical session - EV hardware components	9	4		
	Assignment topics					
Module 5: **Principles for Hybrid Vehicles**	In class	Introduction to Hybrid Vehicles, Battery Chemistry, Efficiency, Definition and Parameters for Hybrid Systems, Electric Motors, Generators and Power	9	3,2		

		Electronics for Hybrid Systems, Control Systems, Hybrid Electric Vehicle Operation, Practical session - Numerical study on powertrain sizing of HEV				
	Assignment topics					

Text Book:

1. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley, 2nd ed, 2012.ISBN-13: 9781119942733
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, Routledge, 3rd Ed, 2021.ISBN-13: 9780367693930
3. Muhammad Ehsani, Mehrdad Ehsani, and Ali Emadi, Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiatives, Springer, 2015.ISBN-13: 9783319360966
4. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 1st Ed, 2014.ISBN-13: 9781466597693
5. "Introduction to Electric Vehicles" – NPTEL course offered by IIT Delhi. Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview.

Reference books:

1. "Electric Vehicle Technology" by Anant V. Kulkarni
2. "Power Electronics and Electric Drives for Traction Applications" by Gonzalo Abad and Sergio Busquets-Monge
3. "Electric Vehicle Integration into Modern Power Networks" by Yasser Abdel-Rady Ibrahim
4. "Electric Vehicles: Prospects and Challenges" edited by Majid Nayeripour, Subhas Chandra Mukhopadhyay, and Vijay Kumar Devabhaktuni
5. "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives" by Christopher Mi

Sub Code: **ME207A2** **Credit: 4(L-3, T-1, P-0)**

ENERGY MANAGEMENT

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To prepare the students for successful career in the energy industry; energy regulation and management agencies; and in the academic and R&D institutions.
2. To produce graduates strong in energy resources, technologies and management fundamentals, and capable in addressing the present and potential future energy problems.
3. To produce energy professionals, who are sensitive to, and well aware of, the energy issues and concerns, and who can apply their specialized knowledge for the sustainable energy management.

Pre-requisites: Basic concept of thermodynamics and Heat Transfer.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand and acquire fundamental knowledge on the science of energy and on both the conventional and non-conventional energy technologies
CO2	Acquire the expertise and skills needed for the energy monitoring, auditing and management, and for the development, implementation, maintenance and auditing of Energy Management Systems
CO3	Analysis and design of energy conversion systems
CO4	Acquire skills in the scientific and technological communications, and in the preparation, planning and implementation of energy projects
CO5	Carry out the cost- benefit analysis of various investment alternatives for meeting the energy needs of the organization.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Energy demand and supply scene of the country, Need of energy management	8	1		
	Assignment topics	Tentative				
Module 2: **Energy audit**	In class	Definition, need, and types of energy audit; Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements; Fuel & energy substitution; Energy audit instruments; Energy Conservation Act	8	1,2		
	Assignment topics	Duties and responsibilities of energy managers and auditors				
Module 3: **Thermal energy management**	In class	Energy conservation in boilers, steam turbines and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps	6	1,2,3		
	Assignment topics	Building Energy Management.				
Module 4: **Energy action planning**	In class	Assessing the Organization, Description and use of Energy Management Matrix, Establishing Organizational Profile, Assessing the Human Element and Technical situation. Strategic approach of organizing the action - Gain Control, Invest, Maintain Control, Understanding Organizational Change. Key elements; Force field analysis; Energy policy purpose,	8	3,4		

		perspective, contents, formulation, ratification; Organizing the management: location of energy management, top management support, managerial function, roles and responsibilities of energy manager, accountability.				
	Assignment topics	Motivation of employees: Information system-designing barriers, strategies; Marketing and communicating: Training and planning.				
Module 5: **Financial analysis of energy efficiency projects**	In class	Principles of Financial Analysis: Inflation, Interest (The time value of Money), Discount Rate, Depreciation, Life Cycle, Salvage Value, Project Costs, Project Benefits, Taxes, Net Cash Flow, Financial Analysis Techniques: Simple Payback Period (SPP), Life-cycle Cost	6	4,5		
	Assignment topics	Annualized Life-cycle Cost, Net Present Value (NPV), Internal Rate of Return (IRR).				

Text Books:

1. CB Smith, Energy Management Principles, Pergamon Press, New York, 1981.
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington, 1980.
3. Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington, 1988.
4. Bureau of Energy Efficiency Study material for Energy Managers and Auditors.

Reference Books:

1. D Patrick and S W Fardo, Energy Management and Conservation, Prentice Hall Inc.
2. J.Krieder and A. Rabi (1994): Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill.
3. Archie, W Culp. Principles of Energy Conservation, McGraw Hill, 1991.
4. P. O'Callaghan: Energy Management, McGraw - Hill Book Company, 1993.
5. C.W. Gellings and J.H. Chamberlin (1993): Demand-Side Management Planning, Fairmont Press.
6. Thuman A and Mehta D Paul, Handbook of Energy Engineering, The Fairmount Press.
7. Kennedy, Turner and Capehart, Guide to Energy Management, The Fairmount Press.
8. Wayne C Turner, Energy Management Handbook, The Fairmount Press.
9. Frank Kreith, Ronald E West, CRC Handbook of Energy Efficiency, CRC Press.
10. Kao Chen, Energy Management in Illumination System, CRC Press.
11. Gellingn, Chamberli, Demand Side Management: Concepts and methods, Penwell.
12. John Elting Treat, Energy Futures: Trading Opportunities, Penwell.
13. Charles M Cotlschalk, Industrial Energy Conservation, John Wiley & Sons.
14. Amit Kumar Tyagi, Handbook on Energy Audits and Management, TERI.

Sub Code: **ME208A2** **Credit: 4 (L-3, T-1, P-0)**

AUTOMOTIVE ELECTRICAL AND ELECTRONICS SYSTEM

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able:

1. To educate students on construction, working and testing of lead acid battery
2. To educate the students on construction and working of different types of ignition system
3. To give knowledge on construction, working of types of starter motors and Alternator and selection of starter motor.
4. To introduce basics and advancement in automobile lighting system
5. To familiarize students with electrical accessories and selection of cables, fuses and Multiplexing

Pre-requisites: Understanding of Automobile engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Explain the construction and testing of lead acid battery, charging of batteries and selection of battery for a vehicle.
CO2	Identify type of ignition system and spark timing.
CO3	Identify the type of starter motor and charging system. Selection of starter motor and alternator for a vehicle.
CO4	Understand the use of cables and lighting system for a vehicle.
CO5	Identify the auto-accessories and multiplexing cables.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Batteries and starting system**	In class	Different types of Batteries – principle, rating, testing and charging. Starter motors characteristics, capacity requirements, Drive mechanisms.	8	1		
	Assignment topics	Starter switches				
Module 2: **Charging system lighting and accessories**	In class	DC Generators and Alternators their characteristics. Control unit – cut out, electronic regulators. Vehicle interior lighting system. Wiring requirements. Lighting design. Dashboard instruments. Horn, trafficator.	8	2		
	Assignment topics	Vehicle exterior lighting system				
Module 3: **Electronic ignition and injection system**	In class	Spark plugs. Advance mechanisms. Different types of ignition systems.	6	3		
	Assignment topics	Electronic fuel injection systems, mono and multi point fuel injection system (MPFI)				
Module 4: **Sensors and microprocessors in automobiles**	In class	Basic sensor arrangements. Types of sensors – oxygen sensor, hot wire anaemometer sensor, vehicle speed sensor, detonation sensor, accelerometer sensor, crank position sensor. Microprocessor and microcomputer controlled devices in automobiles such voice warning system, travel information system, keyless entry system, automatic transmission system.	8	4		
	Assignment topics	electronic steering system.				
Module 5:	In class	Antilock braking system, air bag restraint system,	6	5		

Safety systems		voice warning system, seat belt system, road navigation system.				
	Assignment topics	Anti-theft system				

Text Books:

1. Judge. A.W., "Modern Electrical Equipment of Automobiles", Chapman & Hall, London, 1992.

Reference Books:

1. Young.A.P., & Griffiths.L., "Automobile Electrical Equipment", English Language Book Society & New Press, 1990
2. Spreadbury. F.G., "Electrical Ignition Equipment", Constable & Co Ltd., London, 1962
3. Robert N Brady "Automotive computers and Digital Instrumentation". A Reston Book, Prentice Hill, Eagle Wood Cliffs, New Jersey, 1988.

Sub Code: **ME209A2** **Credit: 4 (L-3, T-1, P-0)**

TRIBOLOGY

Questions to be set: 05 (All Compulsory)

Course Objective: Design of surfaces in contact is a critical problem for mechanical engineering. Tribology is an interdisciplinary course which deals with fundamentals of surface contact, friction, wear and lubrication. Upon completion of this course, the student should be able to:

1. To understand modeling of engineering surfaces, popular surface contact theories, major modes of friction, wear, lubrication and adhesion.
2. Grasp the fundamental knowledge of the friction/lubrication mechanisms and know how to apply them to the practical engineering problem.

Pre-requisites: Knowledge of Engineering Mechanics, Theory of Machine, Automobile basics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understanding of surface topography and know how to model a rough engineering surface.
CO2	Have an understanding about the basics of tribology related sciences and about processes in tribological system, analysis of mechanisms and forms of interaction of friction surfaces.
CO3	Understand Hertz contact and rough surface contact.
CO4	Understand the adhesion theories and analyze the effect of adhesion on friction and wear.
CO5	Apply the methods to reduce the friction for engineering surface

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Engineering Surfaces**	In class	Properties and Measurement: Measurement Methods, Surface Profilometry, Statistical Description of Roughness.	8	1		
	Assignment topics	Introduction: History, Industrial Importance.				
Module 2: **Surface Contact, Adhesion**	In class	Surface Contact: Hertz contact theory, Greenwood-Williamson model, Elastic-plastic contact. Adhesion: Basic Models, Factors influencing Adhesion.	8	2		
	Assignment topics	Effects of Adhesion.				
Module 3: **Friction, Surface Engineering**	In class	Friction: Measurement Methods, Origin of Friction, Friction Theories – adhesion and ploughing, Mechanisms, Friction of Metals, Non-metallic Materials. Surface Engineering: Surface Treatments: Microstructural and Thermochemical Treatments, Surface Coatings: Hard Facing, Vapour Deposition Processes: PVD, CVD, PECVD etc.	8	3		
	Assignment topics	Problem Solving				
Module 4: **Wear, Lubrication**	In class	Wear: Types: Adhesive, Abrasive, Corrosive, Fatigue, Minor Forms: Fretting, Erosion, Percussion, Delamination Theory, Wear Debris Analysis, Wear Testing Methods, Wear of Metals, Ceramics, Polymers.	6	4		

		Lubrication: Basic Equations for Fluid Film Lubrication. Hydrodynamic lubrication -Thrust and Journal bearings,				
	Assignment topics	Squeeze Film Bearings, Hydrostatic lubrication				
Module 5: **Lubrication, Nanotribology**	In class	Gas-Lubrication. Lubrication of rolling element bearings. Boundary lubrication – metal working lubrication. Measurement Tools: Surface Force Apparatus, Scanning Tunnelling Microscope, Atomic / Friction Force Microscope.	6	5		
	Assignment topics	solid film lubrication				

Text Books:

1. P. Sahoo: Engineering Tribology, Prentice Hall-India, New Delhi, 2009.

Reference Books:

1. B. Bhushan: Introduction to Tribology, Wiley, 2002..
2. G W Stachowiak and A W Batchelor: Engineering Tribology, Butterworth-Heinemann, 2005.
3. S.K. Basu, S.N. Sengupta, B.B. Ahuja: Fundamentals of Tribology, Prentice Hall-India, 2005.
4. B C Majumdar: Introduction to Tribology of Bearings, S Chand & Co, 2012.

Sub Code: **ME210A2** **Credit: 4 (L-3, T-1, P-0)**

FLEXIBLE MANUFACTURING SYSTEM

Questions to be set: 05 (All Compulsory)

Course Objective: To facilitate the:

1. Understanding of the concepts and applications of flexible manufacturing systems.
2. Understanding of planning, scheduling, and control of flexible manufacturing systems.
3. Knowledge of computer control in flexible manufacturing systems.
4. Understanding of computer software for flexible manufacturing systems.
5. Understanding of flexible manufacturing systems simulation.
6. Understanding of databases in flexible manufacturing systems.

Pre-requisites: Basic knowledge of manufacturing, management, and automation.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the concepts and applications of flexible manufacturing systems.
CO2	Understand planning, scheduling, and control of flexible manufacturing systems.
CO3	Gain knowledge of computer control in flexible manufacturing systems.
CO4	Understand computer software for flexible manufacturing systems.
CO5	Understand flexible manufacturing systems simulation and database.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction**	In class	Introduction to FMS, development of manufacturing systems, benefits, major elements, types of flexibility.	9	1		
	Assignment topics	Learning more about the concept of the FMS from various web-sites. Writing of a 1 page report on the findings.				
Module 2: **Planning, scheduling, and control of flexible manufacturing systems**	In class	FMS application and flexibility – single product, single batch, n-batch scheduling problem, knowledge based scheduling system.	9	2		
	Assignment topics	Numerical Examples				
Module 3: **Computer control for flexible manufacturing systems**	In class	Introduction, composition of FMS, hierarchy of computer control, computer control of work center and assembly lines, FMS supervisory computer control	7	3		
	Assignment topics	Concept of TaKT Time, Analog and Digital Computer				
Module 4: **Computer software for flexible manufacturing systems**	In class	Types of software specification and selection – trends.	4	4		
	Assignment topics	Recent advancements in FMS software				
Module 5: **FMS simulation and database**	In class	Application of simulation, model of FMS, simulation software, limitation, manufacturing data systems, data flow, FMS database systems, planning for FMS database.	7	5		

	Assignment topics	Case study example of databases in FMS				

Text Books:

1. Jha, N.K. “Handbook of flexible manufacturing systems”, Academic Press Inc., 1991.

Reference Books:

1. Radhakrishnan P. and Subramanyan S., “CAD/CAM/CIM”, Wiley Eastern Ltd., New Age International Ltd., 1994.
2. Raouf, A. and Ben-Daya, M., Editors, “Flexible manufacturing systems: recent development”, Elsevier Science, 1995.
3. Groover M.P., “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt., New Delhi, 1996.
4. Kalpakjian, “Manufacturing Engineering and Technology”, Addison-Wesley Publishing Co., 1995.
5. Taiichi Ohno, “Toyota Production System: Beyond large-scale Production”, Productivity Press (India) Pvt. Ltd. 1992.

Sub Code: **ME211A2** **Credit: 4 (L-4, T-0, P-0)**

Automotive Mechanics for Electric Vehicles

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To familiarise with vehicle dynamics and the elements involved in automotive engineering
2. To utilize software-based sketching and SolidWorks tools to create detailed modular-level designs of electric vehicles, covering chassis, frame, electrical components, battery packs, motors, drive trains, wheels, and tires
3. To provide the modelling skills to system-level design, incorporating interactions between components and assessing system-level behaviour and performance.
4. To compare and contrast different EV standards and classifications, including safety, environmental and performance standards
5. To conduct system-level analysis of electric vehicle performance, simulating ride, handling, stability, and rollover events, and optimizing vehicle designs using MSC Adams software

Pre-requisites: Basics of Mechanical/Automobile Engineering

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Interpret the fundamentals of vehicle dynamics
CO2	Model Electric vehicle at modular levels
CO3	Model Electric vehicle at System level
CO4	Analysing modular level behaviour of Electric vehicles
CO5	Analysing system level behaviour of Electric vehicles

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Automotive Engineering & Vehicle Dynamics**	In class	• Vehicle Dynamics Fundamentals • Tire Mechanics and Dynamics • Suspension Systems, Braking Systems • Aerodynamics, Powertrain Systems • Vehicle Stability Control, Vehicle Safety • Vehicle Dynamics Simulation • Electric and Hybrid Vehicle Dynamics • **Practical session** - EV Dynamics & calculations	9	1		
	Assignment topics					
Module 2: **Sketching for Automotive EV Design [Software-based]**	In class	• Introduction to Automotive Sketching Software • Overview of Vehicle Design Process and Automotive Sketching • Basic Sketching Techniques and Tools in the Software • Sketching Car Exteriors, Interiors and Details • Creating Different Views and Angles of the Vehicle • Rendering and Presenting the Final Sketches • Understanding Proportions, Perspectives and Shapes in Automotive Sketching	9	2		

		• Creating Sketches for Different Vehicle Types (Sedans, SUVs, and Trucks) • Tips and Tricks for Automotive Sketching in the Software				
	Assignment topics					
Module 3: **Advanced EV Modelling Using SolidWorks Tool [Software-based]**	In class	• Introduction to EV Technology and Its Benefits • Basic Vehicle Design Principles • Design and Modelling of Chassis and Frame, Suspension Systems • Design and Modelling of Braking and Steering Systems • Design and Modelling of Electrical Components for EVs • Battery Pack Design and Modelling for 2, 3 and 4 Wheelers • Motor and Drivetrain Design and Modelling for 2, 3 and 4 Wheelers • Design and Modelling of Wheels and Tires for 2, 3 and 4 Wheelers • Testing and Simulation of Vehicle Performance Using Solid Works • Design for Manufacturability and Assembly Considerations • Sustainability and Environmental Impact Considerations in EV Design • **Practical session** - EV hardware components walkthrough	9	3		
	Assignment topics					
Module 4: **Multibody Dynamics with MSC Adams [Software-based]**	In class	• Introduction to MSC Adams Software and Its Capabilities • Setting Up the Modelling Environment in MSC Adams • Multi-body Dynamics Principles and Application to Vehicle Systems Modelling • Vehicle Suspension Systems Modelling, Vehicle Steering Systems Modelling • Vehicle Braking Systems Modelling • **Practical session** - EV Component design & modeling	9	4		
	Assignment topics					
Module 5: **EV Analysis with MSC Adams (Software-based)**	In class	• Tire Force and Characteristics Modelling • Vehicle Dynamics Analysis Including Simulating Ride and Handling, Vehicle Stability and Rollover Events • Optimisation Techniques for Vehicle Designs Using MSC Adams • Integration of MSC Adams Models with Other Software Tools for System-level Simulations and Analysis	9	5		

		• **Practical session** - EV body design analysis				
	Assignment topics					

Text Book:

1. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley, 2nd ed, 2012.ISBN-13: 9781119942733
2. Du, H., Cao, D., & Zhang, H. (n.d.). Modeling, Dynamics, and Control of Electrified Vehicles. Woodhead Publishing, 2017.ISBN-13: 9780128127865
3. Zaman, N.,. Automotive Electronics Design Fundamentals. Springer, 2015. ISBN-13: 9783319359793
4. Gianfranco Pistoia. Electric & Hybrid Vehicles, Elsevier, 1st ed, 2010.ISBN-13: 9781032556796
5. Chau, K. T. Electric Vehicle Machines and Drives: Design, Analysis and Application. John Wiley and Sons, Inc., 2015. ISBN-13: 9781118752524
6. Ehsani, Mehrdad. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. CRC, 2019. ISBN-13: 9780367137465
7. Hughes, Austin. Electric Motors and Drives. Newnes (an Imprint of Butterworth-Heinemann Ltd), 2019. ISBN-13: 9780081026151

Reference books:

1. Hybrid electric Vehicles, Principles and Applications- Chris Ni- WILEY Publications

E Books / MOOCs/ NPTEL:

1. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview

Sub Code: **ME301A2** **Credit:4 (L-3, T-1, P-0)**

INTRODUCTION TO RESEARCH, PUBLICATIONS, AND RESEARCH ETHICS

Questions to be set: 05 (All Compulsory)

Course Objective: Provide students with the fundamental knowledge of research methods and design used in. This will also provide adequate knowledge about various research ethics.

Pre-requisites: None.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Student will gain detailed knowledge on how to start with the research.
CO2	Student will have a clear understanding of various research ethics.
CO3	Students will gain clear understanding regarding the selection of research journal for publication purpose.
CO4	Students will be able to write research articles.
CO5	Students will be able to utilize various indexing and citation database and outline research matrix.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction to Research:**	In class	Meaning and Nature of Research, Types of Research - exploratory, Descriptive, & Causal research, Experimental, what is Research Problem, selecting the Problem, Necessity of and Techniques in defining the problem.	8	1		
	Assignment topics	Formulation of research problem and hypotheses, criteria of Good Research				
Module 2: **Research Ethics and Literature Review**	In class	What is research ethics, Belmont principles, principles of research integrity, types of research misconduct. Importance of literature, types of literatures, process of literature review, source of literatures	8	2		
	Assignment topics	UGC plagiarism regulations, Important aspects to cover during literature review.				
Module 3: **Methods of Data Collection**	In class	Field study, Experimental methods, Survey and web survey methods., Development of scales/questionnaire/schedules/tests.	8	2		
	Assignment topics	Formulation of questions and their testing, Reliability and validity.				
Module 4: **Measurement and sampling**	In class	Sampling –types, frames, unit, sample size and sampling errors, Methods of Sampling- Random sampling and non-random sampling, Sampling techniques Sampling distributions of sample mean and sample variance from Normal population.	6	3,4		
	Assignment topics	Chi-Square, t and F, Z distributions and their properties.				
Module 5: **Research Publications**	In class	Importance of publishing research papers, Publishing Research paper: (a) Preliminaries, Format, Choosing Journal, (b) Title, Running Title (c) Authors: Single and Multi-authorship (d) Writing Abstract (e) Introduction section (f) Materials and Methods Section (g) Results and discussion (h) Figures: Design Principles, Legends, Table components, Graphs: Types, Style, Tables v/s	6	5		

		Graph (i) Acknowledgements (j) References: Different Styles (k) Selecting Keywords (l) Communication with the Editor, Handling Referees' Comments, Galey Proofs.				
	Assignment topics	Writing review articles. Preparing and delivering of oral and poster presentations. Standard Abbreviations and Symbols				

Text Books:

1. Agresti A. 2002. Categorical Data Analysis. 2nd Ed. John Wiley.
2. Arnold BC, Balakrishnan N &Nagaraja HN. 1992. A First Course in Order Statistics.John Wiley.

Reference Books:

1. Huber PJ. 1981. Robust Statistics. John Wiley.
2. Johnson NL, Kotz S &Balakrishnan N. 2000. Continuous Univariate Distributions. John Wiley.

Sub Code: **ME302A2** **Credit:4 (L-3, T-1, P-0)**

TOTAL QUALITY MANAGEMENT

Questions to be set: 05 (All Compulsory)

Course Objective: To facilitate the:

1. Understanding the basics of TQM perspective.
2. Understanding of key principles and strategies for TQM implementation.
3. Application of statistical tools for process improvement.
4. Knowledge of various tools used in TQM.
5. Understanding of different types of Quality Systems.

Pre-requisites: Basic knowledge of management and statistics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the basics of TQM perspective.
CO2	Understand key principles and strategies for TQM implementation.
CO3	Apply statistical tools for process improvement
CO4	Get the knowledge of various tools used in TQM.
CO5	Understand different types of Quality Systems.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **TQM Perspective**	In class	Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs – Analysis, Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.	9	1		
	Assignment topics	Numerical problems on cost of quality,				
Module 2: **TQM Principles & Strategies**	In class	Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.	9	2		
	Assignment topics	Case studies, Numerical problems on supplier rating.				
Module 3: **Statistical Process Control**	In class	The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes, Process capability, Concept of six sigma, New seven Management tools.	8	3		
	Assignment topics	Application of seven tools of quality, Numerical problems.				
Module 4:	In class	Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House	7	4		

TQM Tools		of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.				
	Assignment topics	Application of QFD, Numerical problems.				
Module 5: **Quality Systems**	In class	Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits.	3	5		
	Assignment topics	Case studies on implementation of ISO 9000 and ISO 14001.				

Text Books:

1. Dale H.Besterfield, et al.: Total Quality Management, Pearson Education Asia, 2005. (Eight Indian reprint 2005).
2. Dale H.Besterfield, et al., Total Quality Management, Prentice – Hall of India Private Limited, 2006, Third Edition (Eastern Economy Edition).
3. Subburaj Ramasamy, Total Quality Management, Tata McGraw-Hill, 2006

Reference Books:

1. James R.Evans & William M.Lidsay, The Management and Control of Quality, (5th Edition), South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).
2. Feigenbaum.A.V. "Total Quality Management, McGraw-Hill, 1991.
3. Oakland.J.S. "Total Quality Management Butterworth – Hcinemann Ltd., Oxford, 1989.
4. Narayana V. and Sreenivasan, N.S. Quality Management – Concepts and Tasks, New Age International, 1996.
5. Zeiri. "Total Quality Management for Engineers Wood Head Publishers, 1991.

Sub Code: **ME303A2** **Credit: 4 (L-3, T-1, P-0)**

VEHICLE DYNAMICS

Questions to be set: 05 (All Compulsory)

Course Objective: Provides understanding about the application of basic mechanics principles for dynamic analysis of vehicles and how it responds to diverse in-motion conditions. Upon completion of this course, the student should be able to:

1. To understand the fundamentals of Vehicle dynamics and systems.
2. To evaluate the influence vehicle subsystems on the vehicle behavior.
3. To determine physical and design interpretations from the results.

Pre-requisites: Knowledge of Engineering Mechanics, Theory of Machine, Automobile basics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the fundamentals of Vehicle dynamics and describe various terminologies.
CO2	Explain various performance mode characteristics of the vehicle.
CO3	Analyse ride mode oscillations and compare their characteristics.
CO4	Evaluate the suspension and stability systems concepts and design the same according to requirements.
CO5	Analyse the cornering characteristics of the vehicle and evaluate yaw stability.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Earth and vehicle coordinate system. Longitudinal, lateral and vertical vehicle dynamics. Dynamic axle loads. Road loads - Aerodynamic forces and moments, viscosity effects, separation and its control; aerodynamic lift and its control, styling for minimum drag.	8	1		
	Assignment topics	Rolling resistance, ground effect, grade loads.				
Module 2: **Performance Mode**	In class	Acceleration - Free body diagram of accelerating vehicle, maximum transferable tractive force, Deceleration - free body diagram of decelerating vehicle, maximum decelerating rates, Vehicle performance.	8	2		
	Assignment topics	Acceleration gradability, Deceleration stopping distance, maximum braking force.				
Module 3: **Ride Mode**	In class	Degrees of freedom-single, two and multi degrees of freedom system, free, forced and damped vibration, model of an automobile, magnification factor, transmissibility, vibration absorbers, pitch and bounce motion, oscillation centers, active and semi active suspension, orthogonality of mode shapes,	8	3		
	Assignment topics	Modal analysis. MATLAB based Quarter car modelling and simulation.				
Module 4: **Springing System**	In class	Requirements, sprung mass and un-sprung mass, wheel hop, shimmy, wheel wobble, choice of suspension spring rate, calculation of effective spring rate. Tyres - mechanics, stability of vehicle on slope, on curve and banked road.	6	4		

	Assignment topics	Pacejakas tire model using MATLAB.				
Module 5: **Handling Mode**	In class	Vehicle control-low speed cornering and static Steering- steady-state cornering -steering factors, vehicle control parameters (under steer, neutral steer and over steer), roll steer, compliance steer, ride steer, slip angle steer, steady state handling-lateral acceleration gain, characteristic speed, yaw velocity gain, critical speed..	6	5		
	Assignment topics	Ackerman steering geometry, Effect of braking on vehicle handling, MATLAB based Assignment				

Text Books:

1. Thomas D Gillespie: Fundamentals of Vehicle Dynamics, SAE USA 1992
2. S.S. Rao: Mechanical Vibrations, Pearson Education, Delhi, 2009.

Reference Books:

1. Babu A.K.: Automobile Mechanics, Khanna Publishers, New Delhi.
2. Cole D.E,: Elementary Vehicle Dynamics, Ann Arbor, Michigan, USA, 1972.

Sub Code: **ME304A2** **Credit: 4 (L-3, T-1, P-0)**

DESIGN OF MECHANICAL SYSTEMS

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine component.
2. To give the assurance that his designs will never failure at any circumstances.
3. To apply mechanical engineering design theory to identify and quantify machine elements in the design of commonly used mechanical system.
4. To develop ability to come up with innovative ideas.

Pre-requisites: Basics of strength of materials & Material science, Elementary design.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Demonstrate the ability to design, analysis and sizing of Piston.
CO2	Demonstrate the ability of selection, sizing and analysis of connecting rods
CO3	Demonstrate the ability of selection of bearing types, and sizing and analysis of crankshaft
CO4	Demonstrate the ability of selection of gear types, sizing, analysis and automobile chasis
CO5	Demonstrate the ability of selection, sizing, design, and analysis of other mechanical components/systems

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Synthesis of Mechanisms**	In class	Mechanical design process, design factors, design of mechanical systems - Piston, Connecting rod	7	1		
	Assignment topics	Numerical		1		
Module 2: **Cams**	In class	Crankshaft- Overhung & Center type, Valve gear mechanism	7	2		
	Assignment topics	Numerical		2		
Module 3: **Dynamics of direct acting engine mechanism and governors**	In class	Single plate clutch, Passenger lift,	13	3		
	Assignment topics	Numerical		3		
Module 4: **Gyroscopic effects**	In class	Design of mechanical systems: Concrete mixer, Automobile chassis & suspension. Johnson's method of optimization.	7	4		
	Assignment topics	Numerical		4		
Module 5: **Balancing of rotating masses and reciprocating masses**	In class	Design for manufacture of cast, forged, turned, milled, drilled and ground parts, design for heat treatment, design for assembly.	12	5		
	Assignment topics	Numerical		5		

Text Books:

1. Bhandari V.B., “Design of Machine Elements”, (3e), Tata McGraw Hill Publishing Company, New Delhi, 2010

Reference Books:

1. Trikha S. N., “Machine Design Exercises”, Khanna Publishers, Delhi, 2001.
2. Patil S. P., “Mechanical System Design”, Jaico Publishing House, Mumbai, 2004.
3. George E. Dieter, “Engineering Design”, McGraw Hill Book Co., Singapore, 2000.
4. Mahadevan K. and Balaveera Reddy K., “Machine Design Data Hand Book”, (4e), CBS Publishers and distributors, New Delhi, 1987.

Sub Code: **ME305A2** **Credit: 4 (L-3, T-1, P-0)**

MECHATRONICS

Questions to be set: 05 (All Compulsory)

Course Objective:

1. Understand the Mechatronics system.
2. Know the CNC programming.
3. Understand the control systems

Pre-requisites: Basics of mechanics and mechanics of materials, electronic circuits, mathematics, programming, analysis and design.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Identify key elements of mechatronics system and its representation in terms of block diagram.
CO2	Differentiate the various N/C machines.
CO3	Design and develop a prototype using CNC lathe and milling machines.
CO4	Interlink the mechanical and electrical system.
CO5	Apply the concepts of computer process interfacing.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to Mechatronic: Numerical Control of Machine Tools**	In class	Definition, Basic Concept and elements of Mechatronic system, need and benefit of mechatronic system. Need for N/C machine tools, Basic Components of N/C system, Design Consideration of N/C Machine tools, N/C motion control system.	6	1,2		
	Assignment topics	Application of N/C machines.				
Module 2: **Computer Control of N/C tools: Manual ISO Part Programming**	In class	Problems with N/C machines, Computer Numerical Control, Direct Numerical Control, Adaptive Control machining system, Flexible Manufacturing System, N/C coordinate systems, Preparatory Functions and Miscellaneous Functions, Examples of part programming with CNC Lathe and Milling Machine.	8	1,2,3		
	Assignment topics	Part Program.				
Module 3: **Feedback devices and Counting Devices**	In class	Logic Gates, Encoder, Resolver, Inductosyn, Tachometer. Flip Flops, Counters and Decoders.	7	4		
	Assignment topics	Simple logic assignments.				
Module 4: **Controller: Drives**	In class	Basic concept and elements of Microprocessor, Microcomputer and Assembly Languages. Concept of Hydraulic System, Stepping Motor.	7	4		
	Assignment topics	Application.				
Module 5: **Computer–**	In class	Manufacturing process data, System Interface hardware devices-Transducer, Sensors, Programmable Logic controller (PLC).	8	5		

Process Interfacing	Assignment topics	PLC based programming.				

Text Books:

1. HMT Handbook: Mechatronics, Tata McGraw Hill Publication, 1997.
2. Yorem Koren: Computer Control of Manufacturing Systems, McGraw Hill Book Company.
3. Zimmer & Groover: Computer Aided Design and Manufacture, Prentice Hall of India Pvt. Ltd.
4. Mehta. V. K.: Principles of Electronics, S.Chand & Company Limited.

Reference Books:

1. Mikell P. Groover: Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India Pvt. Ltd.
2. Ramesh S. Gaonkar: Microprocessor, Architecture, Programming and Application, Penram International Publshing (India).

Sub Code: **ME306A2** **Credit: 4 (L-4, T-0, P-0)**

EV Mechanical Design, Development & Analysis

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To explain the basic syntax, variables, commands, M-files, types, operators, decision-making, loops, vectors, matrices, arrays, etc. and programming EV systems in MATLAB
2. To elucidate MATLAB features and Simulink for developing and simulating Electric Vehicle (EV) systems, including modeling EV units, and configuring vehicle components.
3. To utilize MATLAB for modeling electric components, such as DC and induction motors, multi-level inverters, battery chargers, and management systems, ensuring accurate representation in simulation.
4. To explain models of Battery Management Systems (BMS) using MATLAB, incorporating aspects like Li-ion battery pack modeling, DC-DC converters, and motor controller design.
5. To conduct in-depth analysis of Electric Vehicle (EV) powertrain components, including thermal management, using MATLAB and complementary tools like SolidWorks and ANSYS

Pre-requisites: Basics of Electronics/Electrical, basics of programming language

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Illustrate the fundamentals of MATLAB programming
CO2	Relate the MATLAB features for Electric Vehicle Design
CO3	Model Electric components of Electric Vehicle
CO4	Experiment with Battery Management System
CO5	Analyze an EV powertrain system model

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Essentials for Designing & simulation in MATLAB [Software-based]**	In class	• Overview and Environment • Basic Syntax, Variables and Commands • Commands, M-files, and Types • Operators, Decision Making and Loops • Vectors, Matrix, and Arrays • Colon Notation and Numbers • Strings and Functions • Numbers, Plotting and Graphics • Algebra, Calculus, Differential, and Integration • Polynomials and Transforms	9	1		
	Assignment topics					
Module 2: **Programming and Simulation MATLAB [Software-based]**	In class	• Programming EV systems in MATLAB • Simulink and Fitting • Developing SIMULINK Models for Vehicle Units • Advisor and QSS Toolbox • QSS-based Vehicle Control **Practical session** - EV architecture modeling	9	2		
	Assignment topics					
Module 3:	In class	• DC Motor Characteristics • Induction Motor Characteristics	9	3		

Electrical Drives & Mechanical structure interfacing Using MATLAB [Software-based]		• Simulink Model to Calculate Vehicle Configuration • Multi-level Inverter Design and Modelling • **Practical session -** EV Vehicle analysis				
	Assignment topics					
Module 4: **Battery Chargers & Management system modelling Using MATLAB [Software-based]**	In class	• Solar PV-based Charger • DC-DC Converter • Motor Controller Design • Battery Management System Modelling • Modelling of Li-ion Battery Pack Using MATLAB	9	4		
	Assignment topics					
Module 5: **EV Advanced Powertrain Development**	In class	• Introduction to EV Powertrain • Overview, Architecture and Components of EV Powertrain • Thermal Management of EV Powertrain • Modelling and Simulation of EV Powertrain Components in MATLAB • Modelling and Analysis of EV Powertrain Components in SolidWorks • Analysis of EV Powertrain Components in ANSYS • Case Study on Powertrain of Existing Models **Practical session -** EV powertrain complete developing	9	5		
	Assignment topics					

Text Book:

1. William J. Palm III, MATLAB for Engineering Applications, McGraw-Hill, 5th Ed, 2018.ISBN-13: 9781260084719
2. R.B. Choudary I K, Introduction to ANSYS 16.0, International Publishing House Pvt. Ltd, 2nd Ed, 2017.ISBN-13: 9789385909108
3. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 1st Ed, 2014.ISBN-13: 9781466597693
4. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 3rd Ed, 2021.ISBN-13: 9780367693930
5. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview

Reference books:

1. "Advanced Electric Drive Vehicles" by Ali Emadi Publisher: CRC Press ISBN: 978-1439815679
2. "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain Publisher: CRC Press ISBN: 978-1466571260
3. "Electric Vehicle Technology" by H. T. El-Shatter and M. E. El-Shatter Publisher: Artech House ISBN: 978-1596932326

Sub Code: **ME307A2** **Credit: 4 (L-3, T-1, P-0)**

STATISTICAL METHODS FOR DATA ANALYSIS

Questions to be set: 05 (All Compulsory)

Course Objective: The course will help the students to gain basic concepts of applied statistics and data analysis and to imbibe strong foundation of statistics in students.

Pre-requisites: None.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Organize, manage, present data and describe and discuss the key terminology, concepts tools and techniques used in statistical analysis
CO2	Analyze statistical data graphically using frequency distributions and cumulative frequency distributions.
CO3	Analyze statistical data using measures of central tendency, dispersion and location and calculate the simple linear regression equation for a set of data.
CO4	Conduct basic statistical analysis of data, sampling, hypothesis, analysis of variance and calculate and interpret the correlation between two variables.
CO5	Understand several parametric, non-parametric test and different forecasting and time series analysis.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to statistics and presentation of data**	In class	Meaning and scope, Limitation of Statistics, Data, Types of data, Methods of data collection. Presentation of data, Tabulation, Frequency Distribution, Graphical Representation.	7	1		
	Assignment topics	Define basic statistical terms.				
Module 2: **Measures of Central Tendency and Dispersion**	In class	Mean, Median, Quartiles, Deciles, Percentiles, Mode, Geometric mean, Harmonic mean.	7	2		
	Assignment topics	Simple problems of central tendencies.				
Module 3: **Measure of Variations**	In class	Introduction, Range, Mean Deviation, Quartile Deviation, Variance, Standard Deviation, Coefficient of variation, Skewness, kurtosis, measures of skewness.	8	2		
	Assignment topics	Calculations of measures of variations.				
Module 4: **Collection and analysis of data. Sampling techniques.**	In class	Types of correlation, measure of correlation, concept, line of regression X on Y, Line of regression Y on X, Relation between correlation and regression, sampling and sampling distributions, analysis of variance.	7	4, 5		
	Assignment topics	Simple calculations of data analysis				
Module 5: **Hypothesis testing, Forecasting methods &**	In class	Types of hypothesis, types of statistical hypotheses, procedure of hypothesis testing, tests of hypotheses, important parametric tests, non-parametric tests, limitations of the test of Hypotheses. Forecasting methods & Time Series Analysis.	7	5		

Time Series Analysis	Assignment topics	Hypothesis analysis, different parametric and non-parametric tests. Calculations of forecasting techniques.				

Test books

1. Introduction to Statistics by C.B. Gupta, Vikas Publishing House, New Delhi.
2. An Introduction to Statistical Methods and Data Analysis R. Lyman Ott, Micheal Longnecker, Cengage Learning, US.
3. Research methodology by Suresh Chandra, Mohit Kr. Sharma, Mohit Kumar Sharma, Narosa Publishing House, New Delhi.

Reference books

1. Research methodology by R.Paneerselvam, PHI Learning Pvt. Ltd, New Delhi.

Sub Code: **ME308A2** **Credit: 4 (L-3, T-1, P-0)**

FINANCIAL PLANNING AND ANALYSIS

Questions to be set: 05 (All Compulsory)

Course Objective: The course outlines the following objective:

1. Students in the course will gain an in-depth understanding of advanced economics concepts as well as knowledge of how the financial sectors operate.
2. The course focuses on the mathematical properties and relations between concepts of finance and management in investment and other economic activities.
3. Students would be trained in the areas of economic and technical research along with financial modeling.
4. Students will understand factors that affect a company's actual business and future prospects

Pre-requisites: A general knowledge of basic arithmetic and statistics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the philosophy and basic concepts of finance.
CO2	Perform retirement financial planning.
CO3	Design goal based investment planning and understand the risk and reward associated with financial products.
CO4	Perform the fundamental and technical analysis of different security product.
CO5	Perform the technical analysis of different security product.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction to Financial Planning &Insurance**	In class	The financial planning process, Financial Management-General Principles and Behavioral Finance, Ethics of a planner, Regulatory environment. Concepts of Insurance and Risk Management, Life Insurance and General Insurance, Regulatory Framework of Insurance.	6	1		
	Assignment topics	Case Study				
Module 2: **Retirement Planning**	In class	Employee Benefits and Superannuation Benefits, Retirement Needs and Factors in Planning, Regulatory Framework of Retirement Solutions.	6	2		
	Assignment topics	Case Study				
Module 3: **Goal based Investment Planning**	In class	Investment Product Universe and their Applications, Risk Profiling of Products and Investors, Managing Risks, Analysis of Returns, Investment Strategies and Portfolio Management, Regulatory Aspects, Taxation, Advanced Financial Planning.	6	3		
	Assignment topics	Case Study				
Module 4: **security Market & Fundamental Analysis**	In class	Security Market, New Issue Market, Exchanges, AMCs, Investment Alternatives. **Fundamental Analysis** :Introduction, Economic Analysis- Macro Economic Analysis, Economic Forecasting, Indian Approach, Geometric Model Building Approach; Industry Analysis- Importance of Industry Analysis, Classification of Industries, Key Indicators in Analysis, Forecasting Methods,	9	4		

		Conditions and Profitability, Industry Analysis factors, Techniques of Industry Analysis; Company Analysis-Fundamental Analyst's Model, Determining Earnings – Multiplier (P/E) Ratio, Dividend Discount Model of Valuation, Comparative P/E Approach, Growth projection, Forecasting Earnings.				
	Assignment topics	Case Study				
Module 5: **Technical Analysis**	In class	Introduction to technical analysis, Basic Technical Assumptions, Technical Vs Fundamental Analysis, Tools of Technical Analysis, Types of Trend, Charting Techniques-types of chart, candlestick charts, pattern study, price action; Technical Indicators & oscillators, Strategies and psychology , Position Sizing and risk management, Case Study, Live chart study.	9	5		
	Assignment topics	Case Study				

Text Books:

1. G. Victor Hallman, Jerry S. Rosenbloom "Private Wealth Management" McGraw-Hill Education, 9th Edition.
2. Graham, Benjamin. "The intelligent investor" Prabhat Prakashan, 1965.
3. Lynch, Peter, and John Rothchild. "Learn to Earn: A Beginner's Guide to the Basics of Investing" and. Simon and Schuster, 2012.

Reference Books:

1. Schwager, Jack D. "Getting started in technical analysis". Vol. 19. John Wiley & Sons, 1999.
2. John, Murphy. "Technical Analysis of the Financial Markets." New York Institute of Finance 24 (1999): 1-5.

Sub Code: **ME309A2** **Credit:4 (L-3, T-1, P-0)**

AUTOMOTIVE REPAIR AND MAINTENANCE

Questions to be set: 05 (All Compulsory)

Course Objective: The course covers the primary areas of automotive technology by teaching shop management, vehicle systems theory, and troubleshooting and repair processes. Upon completion of this course, the student should be able to:

1. Diagnose the faults that may appear in automobile.
2. Understand the use and servicing requirements of the various automobile components.

Pre-requisites: Knowledge of Automobile and its various components.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the general maintenance aspects, servicing, machines etc of a vehicle
CO2	Understand and analyze the faults developed in an engine and its remedial measure.
CO3	Understand and analyze the faults developed in transmission and driveline of a vehicle.
CO4	Analyze the faults that may develop in clutch and braking system of an automobile.
CO5	Understand and perform an examination of a vehicle's cooling, electrical, and fuel systems.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Maintenance, Workshop Practices, Safety And Tools**	In class	Maintenance – Need, importance, primary and secondary functions, policies - classification of maintenance work - Automotive service procedures – workshop operations – workshop manual - vehicle identification. Safety – Personnel, machines and equipment, vehicles, fire safety - First aid. condition checking of seals, gaskets and sealants. Scheduled maintenance services – service intervals - Towing and recovering	8	1		
	Assignment topics	Vehicle insurance - basic problem diagnosis, Basic tools – special service tools – measuring instruments.				
Module 2: **Engine And Engine Subsystem Maintenance**	In class	General Engine service- Dismantling of Engine components- Engine repair- working on the underside, front, top, ancillaries- Service of basic engine parts, cooling and lubricating system, fuel system, Intake and Exhaust system, electrical system.	6	2		
	Assignment topics	Electronic fuel injection and engine management service - fault diagnosis- servicing emission controls.				
Module 3: **Transmission And Driveline Maintenance**	In class	Clutch- general checks, adjustment and service- Dismantling, identifying, checking and reassembling transmission, transaxle- road testing- Removing and replacing propeller shaft, servicing of cross and yoke joint and constant velocity joints- Rear axle service points- removing axle shaft and bearings- servicing differential assemblies.	6	3		
	Assignment topics	fault diagnosis.				
Module 4: **Steering, Brake, Suspension,**	In class	Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake, Parking brake. Bleeding of brakes. Inspection, Maintenance and Service of Mc person strut, coil spring, leaf spring, shock absorbers.	8	4		

Wheel Maintenance		Inspection, Maintenance and Service of steering linkage, steering column, Rack and pinion steering, Recirculating ball steering service- Worm type steering, power steering system.				
	Assignment topics	Dismantling and assembly procedures. Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation.				
Module 5: **Auto Electrical And Air Conditioning Maintenance**	In class	Maintenance of batteries, starting system, charging system and body electrical -Fault diagnosis using Scan tools. Maintenance of air conditioning parts like compressor, condenser, expansion valve, evaporator - Replacement of hoses- Leak detection- AC Charging	8	5		
	Assignment topics	Fault diagnosis, Vehicle body repair like panel beating, tinkering, soldering, polishing, painting.				

Text Books:

1. Ed May: Automotive Mechanics Volume One and Two, Mc Graw Hill Publications, 2003.
2. Gilles Tim: Automotive Service Inspection Maintenance Repair, 4Th Edition, Cengage Learning.

Reference Books:

1. Bosch Automotive Handbook, Sixth Edition, 2004

Sub Code: **ME310A2** **Credit: 4 (L-3, T-1, P-0)**

FATIGUE AND FRACTURE

Questions to be set: 05 (All Compulsory)

Course Objective: Understanding the mechanics of fatigue and fracture is critical for ensuring the structural integrity of load bearing components in the presence of crack-like flaws. Upon completion of this course, the student should be able to:

1. To understand the principles and applications of linear and nonlinear fracture mechanics.
2. Grasp fracture phenomena in metals and nonmetals will be explored.
3. Understand the mechanics of fatigue and fracture for ensuring the structural integrity of load bearing components in the presence of crack-like defects.

Pre-requisites: Students should have an understanding of Strength of Material and basic elements of mechanical engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Identify and understand the effects of fatigue load.
CO2	Analyze the cumulative damage produced by linear elastic fracture mechanics.
CO3	Analyze fracture initiation and development, as well as the energy associated with them.
CO4	Investigate the micromechanics of fatigue strength in broken bodies to determine their strength.
CO5	Understanding the impact of mean stress on the cyclic plastic zone's size and predicting fatigue crack formation based on LEFM basics.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Linear Elastic Fracture Mechanics (LEFM) I :**	In class	Introduction and review of solid mechanics Introduction to fatigue and fracture of materials, History and Overview. stress concentration effect of flaws, Cracks as stress raisers; The Griffith energy balance, The energy release rate, Crack growth instability analysis and R curve, Stress analysis of cracks: Generalised In-plane Loading (Williams approach),Westergaard stress function.	8	1		
	Assignment topics	Effects of Cracks on Strength; Effect of Cracks on Brittle versus Ductile Behaviours				
Module 2: **Linear Elastic Fracture Mechanics II**	In class	The stress Intensity factor K, Effect of size, Principle of superposition, Weight functions, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of KIC with material; Effects of Temperature and loading rate.; Microstructural Influences on KIC; Mixed mode fracture.	8	2		
	Assignment topics	Behaviour at Crack Tips in Real Materials				
Module 3: **Elastic-Plastic Fracture Mechanics (EPFM)**	In class	Crack tip opening displacement (CTOD), The J-contour integral, J as a nonlinear energy release rate, The HRR singularity, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, Relationship between J and CTOD	8	3		
	Assignment topics	The large strain zone, Laboratory measurement of J				
Module 4:	In class	Micromechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design,fail-	6	4		

Fatigue of Materials I		safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach, Cyclic deformation and the strain-life (ε-N) approach,				
	Assignment topics	Fatigue analysis				
Module 5: **Fatigue of Materials II**	In class	Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth, Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories,	6	5		
	Assignment topics	Load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.				

Text Books:

1. T L Anderson: Fracture Mechanics: fundamentals and applications.
2. S. Suresh: Fatigue of materials, Second Edition, cambridge university press.

Reference Books:

1. J.F.Knott Butterworths: Fundamentals of Fracture Mechanics.
3. Fatemi, Fuchs and Stephens: Metal Fatigue in Engineering Stephens, John Wily.
4. F.Ellyin: Fatigue Damage, Crack Growth and Life Prediction, Chapman & Hall.
5. D. Broek: Elementary Engineering Fracture Mechanics, Kluwer Academic.

Sub Code: **ME311A2** **Credit: 4 (L-3, T-1, P-0)**

ROBOT KINEMATICS AND DYNAMICS

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To develop the student's knowledge in various robot structures and their workspace.
2. To develop student's skills in performing spatial transformations associated with rigid body motions.
3. To develop student's skills in perform kinematics analysis of robot systems.
4. To provide the student with some knowledge and analysis skills associated with trajectory planning.

Pre-requisites: Dynamics, Computer Programming and Problem Solving.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics.
CO2	Demonstrate an ability to apply spatial transformation to obtain forward kinematics equation of robot manipulators.
CO3	Demonstrate an ability to solve inverse kinematics of simple robot manipulators.
CO4	Demonstrate an ability to generate joint trajectory for motion planning.
CO5	Gain some knowledge and skills associated with robot control.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots.	5	1		
	Assignment topics	NA				
Module 2: **Direct & Inverse Kinematics**	In class	Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axis robots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two Axis Three axis, Four axis and Five axis robots.	8	2		
	Assignment topics	Problems on kinematic analysis of robot				
Module 3: **Workspace Analysis**	In class	Workspace analysis of Four axis, five axis and Six axis robots, Perspective transformation, structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures.	7	3		
	Assignment topics	Problems workspace analysis				
Module 4: **Differential Motion and Statics**	In class	The tool Configuration jacobian matrix for three axis and, four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.	8	4		
	Assignment topics					

Module 5: **Dynamic Analysis and Forces And Trajectory Planning**	In class	Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot. Trajectory planning, pick and place operations, Continuous path motion, Interpolated motion, Straight line motion.	8	4,5		
	Assignment topics					

Text Books:

1. Robert J. Schilling, ―Fundamentals of Robotics Analysis and Control‖, PHI Learning, 2009.
2. Niku S B, ―Introduction to Robotics, Analysis, Systems, Applications‖, Prentice Hall, 2001.

Reference Books:

1. John J Craig, ―Introduction to Robotics‖, Pearson, 2009.
2. Deb S R and Deb S, ―Robotics Technology and Flexible Automation‖, Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S K, ―Introduction to Robotics‖, Tata McGraw Hill Education Pvt. Ltd, 2010.

Sub Code: **ME312A2** **Credit: 4 (L-4, T-0, P-0)**

EV Product Development, Homologation & Hydrogen

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To guide in comprehending the intricacies of Electric Vehicle (EV) regulations and standards, emphasizing categories, compliance procedures, and homologation processes.
2. To instruct and support learners in navigating the EV certification journey, encompassing the various testing protocols, adherence to standards, and the acquisition of necessary approvals.
3. To provide practical training on the complete product development life cycle for Electric Vehicles, including segment selection, design planning, validation, competitor analysis, and feasibility assessments.
4. To explain the foundational principles of hydrogen-based technology, covering essential hydrogen properties, fuel cell techniques, systems, and safety protocols.
5. To explain the construction and integration of hydrogen fuel cells into hybrid electric vehicles.

Pre-requisites: Basics of design, manufacturing and product development

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Interpret the various steps involved in the regulations and standards of Electric Vehicle
CO2	Demonstrate the certification process of EV
CO3	Experiment with the EV Product Development cycle
CO4	Illustrate the principles of Fuel cells
CO5	Organize the fuel-cell based Hybrid vehicle construction

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **EV Design, Manufacturing & Management**	In class	• Introduction to EV (2W, 3W & 4W) Market and Opportunities • Electric Vehicle Design Procedure and ICE Model • Introduction to EV Management (Categories, Regulations and Standards) • EV Homologation and Testing • FAME India and Manufacturing Guidelines	9	1		
	Assignment topics					
Module 2: **EV Testing, Certification & Market analysis**	In class	• EV Certification Process • EV Charging, Electric Vehicles and Retrofitting • Motor Technology and EV Motor Market Analysis • EV Categories and Proposed Changes, EV Retrofitting Business • Battery Technology in EV, EV Battery Market Analysis • **Practical session** - Conducting a market analysis of the EV industry	9	2		
	Assignment topics					
Module 3:	In class	• Introduction to Product Development Plan	9	3		

EV R&D Product Development		• Segment Selection • Product Design Plan • Product Validation Plan • Vehicle Dynamics Selection • Product Design Validation • Product Specification - Competitor Analysis • Selection of Off-the-Shelf Parts • Development Methods • Product Development Plan • Unit Economics, Design Feasibility • Design for Manufacturing, DFMEA and PFMEA • Business Plan, Product Launch • POC/MVP/Working Prototype • **Practical session** – Using the market research to develop a business plan for an EV manufacturer				
	Assignment topics					
Module 4: **Hydrogen Fuel Cells**	In class	• Introduction to Future Mobility • Why Hydrogen-based Technology • Essentials of Hydrogen • How Does Hydrogen Compare to Hydrocarbon Fuels in Terms of Energy, Flammability and Safety • Hydrogen Fuel Cells, Use of Hydrogen in IC Engines • Hydrogen Fuel Cell Techniques and Systems • Fuel Cell Engine Safety and Maintenance	9	4		
	Assignment topics					
Module 5: **Hybrid Vehicles & Fuel Cells**	In class	• Fuel Cell Hybrid Electric Vehicle Acts, Codes, Regulations and Guidelines • Maintenance and Fuelling Facility Requirements • Fuel Cells in Hybrid Electric Vehicles and Pure Electric Vehicles • Auxiliary Power Generation Using Hydrogen • Types of Fuel Cells and Techniques Used • Fuel Stack Module Construction • Fuel Cell Performance, Characteristics, Polarisation, Stoichiometry Effects, Temperature and Pressure Effects • **Practical session** – Study on Hydrogen fuel cell with MATLAB/SIMULINK	9	5		
	Assignment topics					

Text Book:

1. Beate Müller, and Gereon Meyer. Electric Vehicle Systems Architecture and Standardization Needs. Springer, 25 Feb. 2015.ISBN-13: 9783319360966

2. Detlef Stolten, and Bernd Emonts. 18th World Hydrogen Energy Conference 2010 – WHEC 2010 Proceedings Speeches and Plenary Talks. Forschungszentrum Jülich, 2012.ISBN-13: 9783893366583
3. Fijalkowski, B T. Automotive Mechatronics: Operational and Practical Issues. Springer Science & Business Media, 25 Nov. 2010.ISBN-13: 9789400704084
4. Lachmayer, Roland, et al. Innovative Product Development by Additive Manufacturing 2022. Springer Nature, 8 Apr. 2023.ISBN-13: 9783031272608
5. Michael H. Westbrook, The Electric Car: Development and Future of Battery, Hybrid and Fuel-Cell Cars (Iee Power & Energy Series, 38), ISBN 2001.9780852960134
6. ÖchsnerAndreas, and Springerlink (Online Service. Engineering Applications for New Materials and Technologies. Cham, Springer International Publishing, 2018.ISBN-13: 9783319891972
7. Weber, Julian. Automotive Development Processes. Springer Science & Business Media, 22 June 2009.ISBN-13: 9783642012525
8. Wood, David L. Impacting Rapid Hydrogen Fuel Cell Electric Vehicle (FCEV) Commercialization : System Cost Reduction and Subcomponent Performance Enhancement. Warrendale, Sae International, Cop, 2016.ISBN-13: 9780768082562

Reference books:

1. Electric and Hybrid Vehicles- Tom Denton, Routledge Publishers-ISBN 9780367273231
2. Hybrid electric Vehicles, Principles and Applications- Chris Ni- WILEY Publications

E Books / MOOCs/ NPTEL:

1. "Electric Vehicles and Mobility" - offered by Delft University of Technology on edX
   Link: https://www.edx.org/professional-certificate/electric-vehicles-and-mobility
2. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview

Sub Code: **ME401A2** **Credit: 4 (L-3, T-1, P-0)**

PERSONNEL MANAGEMENT AND INDUSTRIAL RELATIONS

Questions to be set: 05 (All Compulsory)

Course Objective: This course covers the basics of working of personnel department, the detailed process of recruitment and appraisal phenomena in an organization. This course also emphasizes on handling the industrial relations, disputes, and the importance of trade unions.

Pre-requisites: None.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand and analyze the current issues, trends, practices, and processes in personnel management
CO2	Identify the basics of recruitment and appraisal process and the appropriate ways to determine wage and salary.
CO3	Analyze the importance of industrial relations and explore the welfare measures adopted to handle indiscipline and grievances between the stakeholders like government, companies, and employees.
CO4	Apply the grievance handling and dispute settlement procedure within and outside the organization.
CO5	Identify and understand the importance of trade unions and its importance in business

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Personnel management**	In class	Objectives, Functions of Personnel Management, Process of Human Resource Planning	4	1		
	Assignment topics	Definitions and Terminology				
Module 2: **Recruitment and Appraisal**	In class	Steps in recruitment process, Sources of recruitment, methods of recruitment. Promotions, Demotions, Transfers, Separation, Absenteeism and Turn over, Wage and Salary administration Performance Appraisal, Methods of Performance evaluation.	8	2		
	Assignment topics	Case studies, sample collection of recruitment advertisement in newspaper, Sample preparation of Appraisal form				
Module 3: **Industrial Relations**	In class	Functional Requirements, Employee's participation in management. Grievances and Grievance Handling, Act of Indiscipline/ Misconduct, Principles for maintenance of discipline.	8	3		
	Assignment topics	Case studies if any				
Module 4: **Industrial Disputes**	In class	Procedure for the Settlement of Disputes, Government and Industrial Relations, Organs of Industrial Peace.	8	4		
	Assignment topics	Case studies if any				
Module 5: **Trade Unions**	In class	Objectives and Functions, Growth of Trade Union Movement, Factors Affecting Growth of Trade Unions, Essentials of a Successful Trade Union.	8	5		
	Assignment topics	Importance of unions, history				

Text Books:

1. Mamoria C B and Gankar S V- Personnel Management, (23e), Himalaya Publishing House,

2. Megginson L C, Personnel and Human Resources Administration, (3e), R. D. Irwin

Reference Books:

1. Beach D S - Personnel: The Management of the People at Work, (3e), Macmillan, 1975.
2. Yoder D - Handbook of Personnel Management and Labor Relations, Volume 1, McGraw Hill

Sub Code: **ME402A2** **Credit: 4 (L-3, T-1, P-0)**

ROBOTICS AND AUTOMATION

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To demonstrate and understand how to program robots and computers.
2. To control manufacturing automation, with an emphasis on the team approach to problem solving in a work environment.
3. To utilize state of the art equipment like the Tetrix Robotic System, Scorbot ER-4 Manipulator, and peripherals that includes conveyers, sliders, and turntables.

Pre-requisites: Basic of electronics and Programming background.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Describe in detail how industrial robot systems are used, structured, operate and operation of robotic tooling, including actuators, mechanics and sensors.
CO2	Describe other parts of automated manufacturing systems, including process control, component flows, machine safety and personal safety.
CO3	Describe computer-aided production tools and data communication within an industrial robotics network.
CO4	Identify fundamental issues within sustainable industrial development from an automation perspective and be able to exemplify the consequences of these.
CO5	Implement and present a basic automation task with an industrial robot, including pilot study, online and offline programming and evaluation of the results, based on a given specification.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Fundamental Concepts of robotics**	In class	History, present status & future trends - Robotics & automation - Laws of Robotics - Robot definitions - Robotics systems & robot anatomy - Specification of Robots - resolution, Repeatability & accuracy of a manipulator.	6	1,2		
	Assignment topics					
Module 2: **Robot drives & power transmission systems & control**	In class	Robot drive mechanisms, hydraulic – electric - pneumatic drives, mechanical transmission method – Rotary - to /rotary motion conversion, rotary –to linear motion conversion - End effectors.	8	1,2		
	Assignment topics					
Module 3: **Sensors & Intelligent Robots**	In class	Sensory devices - Non optical - position sensors - optical position sensors - Velocity sensors - Proximity sensors - contact & non - contact type - touch & slip sensors - Force & torque sensors - Al & Robotics. Computer Vision for Robotics Systems.	8	1, 2, 3		
	Assignment topics					
Module 4: **Robot Cell Design & Control**	In class	Specification of commercial robots - Robots design & process specification - Motor selection in the design of a robotic joint - Robot cell layouts - Economic & social aspect of robotics.	8	4		

	Assignment topics					
Module 5: **Application of Robots**	In class	Capabilities of Robots - Robotics applications - Obstacle avoidance - Robotics in India - The future of robotics Factor Automation - Hierarchical computer control.	6	5		
	Assignment topics					

Text Books:

1. Richard D.Klafter, Thomas A.Chmielewski Michael Negin, Robotics Engg-An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P.Ltd.1989.
2. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998
3. Shiman Y.Nof,"Handbook of Industrial Robotics. "John Willey & Sons, New York, 1985.
4. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., Industrial Robotics, McGraw-Hill Singapore, 1996.

Reference Books:

1. Fu.K.S.Gomalez, R.C.Lee, C.S.G,"Robotics: Control, Sensing, Vision& Intelligence", MGH book co.1987.
2. MikellP.Grooveret.al,"Industrial Robots-Technology, Programming & application", MGH,New York, 1980.
3. Deb.S.R, Robotics technology and flexible Automation, John Wiley, USA 1992.
4. Asfahl C.R., Robots and manufacturing Automation, John Wiley, USA 1992.

Sub Code: **ME403A2** **Credit: 4 (L-4, T-0, P-0)**

EV FEA Analysis

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To explain how to effectively use ABAQUS and ANSYS software for advanced simulations in Electric Vehicle (EV) engineering
2. To impart practical skills in preparing models for analysis using HyperMesh, including tasks like geometry cleanup, mesh creation, and enhancing element quality for Finite Element Analysis (FEA)
3. To conduct detailed structural analyses on EV components, assessing stress, strain, and thermal effects, ensuring structural integrity and safety
4. To perform Computational Fluid Dynamics (CFD) techniques for analyzing battery thermal management, vibration, fatigue, and external cooling mechanisms in Electric Vehicles
5. To design and analyze EV structures, with a focus on ensuring the safety and integrity of battery packs, including vulnerability analysis and structural integrity assessments

Pre-requisites: Basics of Design and Finite Element Methods

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Model the structure of EV using ABAQUS & ANSYS
CO2	Inspect the structural models of EV
CO3	Analyze the structural characteristics of components using FEA
CO4	Categorize Mechanical & electrical properties of materials and Computational FD of EV system
CO5	Examine the transient analysis of EV

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **EV Design and Structural Analysis with Altair HyperMesh**	In class	• Theory of FEA/CAE • Introduction to HyperMesh • Creating and Modifying Geometry • Geometry Clean-up and Defeature • Introduction to 2D Meshing • Introduction to 3D Meshing • Element Quality • Mesh Edit • Introduction to Plastic Meshing • Introduction to 1D Meshing • Modal Analysis • Linear Static Analysis • Buckling Analysis • Connectors • **Practical session** - Optimization techniques using HyperMesh	9	1		
	Assignment topics					
Module 2: **ABAQUS in EV Engineering [Software-based]**	In class	• Introduction to Abaqus Software • Fundamentals of FEA-Stress • About Abaqus Software-Features • Applications of Abaqus Software in Different Industries	9	2		

		• Simple Modelling in Abaqus Software • Create Material and Create Assembly • Create Steps, Loads, Boundary Conditions • Generate Mesh, Result Visualization • **Practical session** - Multiphysics analysis using Abaqus				
	Assignment topics					
Module 3: **Finite element Analysis of EV structural components [Software-based]**	In class	• One Dimensional Analysis • Linear Static Analysis and Linear Buckling Analysis • Heat Transfer Analysis • Non-linear Analysis • Dynamic Simulation-Modal Analysis • Impact Analysis • Time-Dependent Load Analysis	9	3		
	Assignment topics					
Module 4: **ANSYS in EV Engineering [Software-based]**	In class	• Basics of Finite-Element Analysis (FEA) along with ANSYS Tool and Software Interface • Essential Mechanical and Electrical Properties of Materials • Various Case Studies on ANSYS Mechanical • Basics of Computational Fluid Dynamics (CFD) • Various Case Studies on ANSYS Fluent • **Practical session** – FEA analysis using ANSYS	9	4		
	Assignment topics					
Module 5: **Dynamic Simulation and Transient Analysis [Software-based]**	In class	• Simulation of Battery Thermal Management in Electric Vehicle • Vibration and Fatigue Analysis of Battery Pack • Simulation of Structural Integrity for Motor Mount • Thermal Analysis of Liquid-Cooled Radiator • CFD Study of External Cooling Mechanism for Battery Pack • **Practical session** - Vulnerability analysis	9	5		
	Assignment topics					

Text Book:

1. Gokhale, Nitin S. Practical Finite Element Analysis. FINITE TO INFINITE, 2008.ISBN-13: 9788190619516
2. Mohamed Amine Fakhfakh. Modeling and Simulation for Electric Vehicle Applications. BoD – Books on Demand, 5 Oct. 2016.ISBN-13: 9789535126362
3. Narayana, Lakshmi, et al. Advances in Automation, Signal Processing, Instrumentation, and Control. Springer Nature, 4 Mar. 2021. ISBN 9789811582202

4. P Seshu. Textbook of Finite Element Analysis. New Delhi, Prentice-Hall Of India, 2010.ISBN-13: 9788120323155
5. Turner, John. Progress in Modeling and Simulation of Batteries. SAE International, 15 June 2016.ISBN-13: 9780768082821
6. Y Nakasone, et al. Engineering Analysis with ANSYS Software. Amsterdam, Butterworth-Heinemann, 2018.ISBN-13: 9780081021644

Reference books:

1. "Introduction to the ANSYS Parametric Design Language (APDL): A Guide to the ANSYS Parametric Design Language" by Paul D. Kurowski Publisher: SDC Publications ISBN: 978-1585039141
2. "Abaqus Analysis User's Guide" by Dassault Systems Publisher: Dassault Systems ISBN: N/A (Available as part of the Abaqus documentation)
3. "A First Course in Computational Fluid Dynamics" by Patrick J. Roache Publisher: Society for Industrial and Applied Mathematics (SIAM) ISBN: 978-0898714822
4. "Introduction to Computational Fluid Dynamics: Development, Application and Analysis" by Atul Sharma Publisher: CRC Press ISBN: 978-0367333620

E Books / MOOCs/ NPTEL:

1. "Electric and Hybrid Vehicles: Design and Analysis" by Omar Faruque
2. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview
3. "Introduction to Electric Vehicles" by Gregory L. Reed and Robert Hebner

Sub Code: **ME404A2** **Credit:4 (L-3, T-1, P-0)**

DECISION MAKING TECHNIQUES

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To aid in the comprehension of the traditional decision making techniques and also to understand the modern structured decision making approaches.
2. To aid in gaining knowledge of decision making techniques and their applications in manufacturing environment as well as other business decisions.
3. To aid in cultivating and applying the critical decision making skills in some specific industrial applications.

Pre-requisites: Basic knowledge of Microsoft excel and fluency in algebra.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Apply the concepts of structured decision making to develop the decision matrix.
CO2	Evaluate the weights of criteria and normalize the values of decision matrix.
CO3	Implement the complete decision making approach using PROMETHEE method to solve engineering and business specific problems.
CO4	Apply the compromise and outranking methods to solve decision related problems in engineering.
CO5	Employ distance based MCDM approaches along with some new methods to solve decision problems, also analyze the ranking behavior of the results obtained using different MCDM methods.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction to Structured Decision Making**	In class	Understand the basic principles of structured decision making approaches, basic idea of criteria, alternative and decision problems.	4	1		
	Assignment topics	Definitions, Terminologies				
Module 2: **Estimation of Weights and Normalization methods**	In class	Importance of criteria weight and its estimation, Different weighting methodology, Analytical Hierarchy Process, Case studies using AHP, Entropy method, Problem solving using Entropy method. Importance of normalization, Different normalization techniques, Calculations using normalization techniques	7	2		
	Assignment topics	Case studies and problem solving				
Module 3: **Preferential ranking methods**	In class	PROMETHEE / COPRAS, case studies, Problem solving	7	3		
	Assignment topics	Case studies and problem solving				
Module 4: **Compromise ranking method and Outranking methods**	In class	VIKOR and ELECTRE method, Previous case studies , Problem solving	8	4		
	Assignment topics	Case studies and problem solving				
Module 5:	In class	TOPSIS method, EDAS method, case studies, Problem solving.	10	5		

Distance based method and some new MCDM methods		Discussion on some new MCDM methods, case studies, Problem solving.				
	Assignment topics	Case studies, Analysis and problem solving				

Text Books:

1. Raju K.S ., Nagesh Kumar D.,(2014) - Multi-criterion Analysis in Engineering and Management, Prentice Hall of India (PHI) Learning Pvt. Ltd, New Delhi.
2. A. Jahan, K. L. Edwards -, Multi-criteria Decision Analysis for Supporting the Selection of Engineering Materials in Product Design. Butterworth-Heinemann, 2013.

Reference Books:

1. Zopounidis, C.; Pardalos, P. M. (Eds.). 2010. Handbook of multi-criteria analysis. Berlin, Heidelberg: Springer-Verlag. 455 p. http://dx.doi.org/10.1007/978-3-540-92828-7.

Sub Code: **ME405A2** **Credit: 4 (L-4, T-0, P-0)**

EV Data Analytics & Cyber Security

Questions to be set: 05 (All Compulsory)

Course Objective:

1. Understand the importance of cybersecurity in the automotive industry and its impact on vehicle systems.
2. Analyse automotive megatrends and their implications for cybersecurity in vehicle development processes.
3. Gain knowledge of the data analytics pipeline and its application in the automotive industry, in the context of electric vehicles (EVs).
4. Apply statistical analysis techniques to EV data, including collection, pre-processing, regression, classification, and clustering, for insights and decision-making.
5. Explore the role of data analytics in automotive system data collection, focusing on sensors, and investigate predictive maintenance techniques.

Pre-requisites: Basics of Data Analytics

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Infer the principles of cyber security in Automotive products
CO2	Interpret the mobility services in Autonomous vehicles
CO3	Select and use Data acquisition techniques
CO4	Test for Fault, RUL in automotive systems
CO5	Utilize Bigdata analytics for Automotive data

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Cyber Security for Automotive Vehicle Systems**	In class	• Mobile Apps for Connected Car • Car Hailing and Ride Sharing • Connected Parking and Automated Valet Parking • ADAS and Autonomous Driving	9	1		
	Assignment topics					
Module 2: **Advanced Mobility Services**	In class	• Mobile Apps for Connected Car • Car Hailing and Ride Sharing • Connected Parking and Automated Valet Parking • ADAS and Autonomous Driving	9	2		
	Assignment topics					
Module 3: **Data Analytics for EV and Automotive Systems**	In class	• Introduction to Data Analytics and Its Application in the Automotive Industry • Understanding of the Data Analytics Pipeline • Overview of Data Analytics, Its Tools, and Techniques • EV Data Collection and Analysis • Sensors and Data Collection in EVs • Data Acquisition and Pre-processing • Statistical Analysis of EV Data	9	3		

		• Practical session - Conducting a vulnerability assessment on an in-vehicle network, and developing a report on the findings with recommendations for mitigations				
	Assignment topics					
Module 4: **Automotive System Data Collection and Analysis**	In class	• Automotive Systems (such as Engines, Transmissions, Brakes, etc.) • Data Acquisition and Pre-processing • Statistical Analysis of Automotive System Data • Regression, Classification and Clustering • Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) • Predictive Maintenance Techniques in Automotive Systems • Fault Detection and Diagnosis • Remaining Useful Life (RUL) Prediction • **Practical session** - Developing predictive maintenance models for automotive systems	9	4		
	Assignment topics					
Module 5: **Introduction to Big Data Platforms**	In class	• Introduction to Big Data Platforms and Tools (such as Hadoop, Spark, and Kafka) • How to Use Big Data Platforms to Process and Analyze Automotive Data • **Practical session** - Case studies showcasing the application of data analytics in the automotive industry	9	5		
	Assignment topics					

Text Book:

1. Adams Niall M, et al. Data Science for Cyber-Security. World Scientific, 25 Sept. 2018.ISBN-13: 9781786345639
2. Chowdhury, Mashrur A., et al. Data Analytics for Intelligent Transportation Systems. Amsterdam, Elsevier, 2017.ISBN-13: 9780443138782
3. Janeja, Vandana P. Data Analytics for Cybersecurity. Cambridge ; New York, Ny, Cambridge University Press, 2022.ISBN-13: 9781108415279
4. McQueen, Bob. Big Data Analytics for Connected Vehicles and Smart Cities. Boston, MA, Artech House, 2017.ISBN-13: 9781630813215
5. McKinney, Wes. Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter.ISBN-13: 9781098104030
6. Root, Alex. Python for Data Analytics. 6 Sept. 2019.ISBN-13: 9781691418831
7. Runkler, Thomas A. Data Analytics. Springer Nature, 13 May 2020. ISBN 9783658297794
8. Verma, Rakesh M, and David J Marchette. Cybersecurity Analytics. CRC Press, 27 Nov. 2019.ISBN-13: 9781032401003

Reference books:

1. "Big Data Analytics for Cyber-Physical Systems: Machine Learning for the Internet of Things" by Tarek Abdel Zaher, Shiguang Wang, and Mohamed Youssef
2. "The Car Hacker's Handbook: A Guide for Penetration Testers" by Craig Smith
3. "Cybersecurity for Connected Cars: Protecting Your Vehicle against Cyber Attacks" by Sujit Ghosh
4. "Electric Vehicle Integration into Modern Power Networks" by Pal B. Ladjevardi and Jinfeng Ren

5. "Data Analytics for Renewable Energy Integration" by Josep M. Guerrero and Babak Badrzadeh

MECHANICAL ENGINEERING
(VALUE ADDED SUBJECTS)

Sub Code: **ME201A5** **Credit: 1 (L-0, T-0, P-2)**

PROJECT BASED LEARNING-I

Course Objective: To motivate the students for practical application of knowledge gain

Pre-requisites: Knowledge of Mechanical engineering subjects taught.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Utilize the theoretical knowledge on actual application.
CO2	Visualize the practical application of mechanical equipments.
CO3	Able to develop new concept for various applications.

Project based learning-I should be done by the students in 3th semester for which a teacher is assigned to the student(s) under whom he/she/they will work. Minimum contact hour per week is 4 hrs.

Sub Code: **GN201A1** **Credit: 3 (L-2, T-1, P-0)**

UNIVERSAL HUMAN VALUES-II
UNDERSTANDING HARMONY and ETHICAL HUMAN CONDUCT

Questions to be set: 05 (All Compulsory)

Course Objective:
This introductory course input is intended:
1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity that are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much needed orientational input in value education to the young enquiring minds.

Pre-requisites: None. However, it is desired that students may have gone through UHV-I: Universal Human Values-Introduction

Course Outcomes (CO): This will equip mechanical engineers with the analytical tools required for building robust systems.

CO	STATEMENT
CO1	Students are expected to understand self-exploration and Basic Human Aspirations.
CO2	To understand harmony in themselves (Human being).
CO3	To become more aware of their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
CO4	They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:
1. Holistic vision of life
2. Socially responsible behaviour
3. Environmentally responsible work
4. Ethical human conduct
5. Having Competence and Capabilities for Maintaining Health and Hygiene
6. Appreciation and aspiration for excellence (merit) and gratitude for all

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Interpolation**	In class	Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education) Understanding Value Education **Practice Session PS1** Sharing about Oneself Self-exploration as the Process for Value Education Continuous Happiness and Prosperity – the Basic Human Aspirations **Practice Session PS2** Exploring Human Consciousness Happiness and Prosperity – Current Scenario	9			

		Method to Fulfil the Basic Human Aspirations **Practice Session PS3** Exploring Natural Acceptance				
Module 2: **Numerical differentiation and integration**	In class	Understanding Human being as the Co-existence of the Self and the Body Distinguishing between the Needs of the Self and the Body **Practice Session PS4** Exploring the difference of Needs of Self and Body The Body as an Instrument of the Self Understanding Harmony in the Self **Practice Session PS5** Exploring Sources of Imagination in the Self Harmony of the Self with the Body Programme to ensure self-regulation and Health **Practice Session PS6** Exploring Harmony of Self with the Body	9	2		
Module 3: **Numerical solution of algebraic and transcendental equations**	In class	Harmony in the Family – the Basic Unit of Human Interaction 'Trust' – the Foundational Value in Relationship **Practice Session PS7** Exploring the Feeling of Trust 'Respect' – as the Right Evaluation **Practice Session PS8** Exploring the Feeling of Respect Other Feelings, Justice in Human-to-Human Relationship Understanding Harmony in the Society Vision for the Universal Human Order **Practice Session PS9** Exploring Systems to fulfil Human Goal	9	3		
Module 4: **Solution of systems of linear equations**	In class	Understanding Harmony in the Nature Interconnectedness, self-regulation, and Mutual Fulfilment among the Four Orders of Nature **Practice Session PS10** Exploring the Four Orders of Nature Realizing Existence as Co-existence at All Levels The Holistic Perception of Harmony in Existence **Practice Session PS11** Exploring Co-existence in Existence	6	4		
Module 5: **Numerical solution of initial value problems**	In class	Natural Acceptance of Human Values Definitiveness of (Ethical) Human Conduct **Practice Session PS12** Exploring Ethical Human Conduct A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order Competence in Professional Ethics **Practice Session PS13** Exploring Humanistic Models in Education Holistic Technologies, Production Systems and Management Models-Typical Case Studies Strategies for Transition towards Value-based Life and Profession **Practice Session PS14** Exploring Steps of Transition towards Universal Human Order	9	5		

Content for Practice Sessions (Tutorials)

In order to connect the content of the proposals with practice (living), 14 practice sessions have been designed. The full set of practice sessions is available in the Teacher's Manual as well as the website.

Practice Sessions for Module 1 – Introduction to Value Education

PS1 Sharing about Oneself
PS2 Exploring Human Consciousness
PS3 Exploring Natural Acceptance

Practice Sessions for Module 2 – Harmony in the Human Being

PS4 Exploring the difference of Needs of Self and Body
PS5 Exploring Sources of Imagination in the Self
PS6 Exploring Harmony of Self with the Body

Practice Sessions for Module 3 – Harmony in the Family and Society

PS7 Exploring the Feeling of Trust PS8 Exploring the Feeling of Respect
PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for Module 4 – Harmony in the Nature (Existence)

PS10 Exploring the Four Orders of Nature
PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics

PS12 Exploring Ethical Human Conduct
PS13 Exploring Humanistic Models in Education
PS14 Exploring Steps of Transition towards Universal Human Order

Text books:

1. A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034- 47-1

Teacher's Manual:

1. Teachers' Manual for *A Foundation Course in Human Values and Professional Ethics*, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2

Reference books:

1. Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj – Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

Sub Code: **ME202A5** **Credit: 1 (L-0, T-0, P-2)**

PROJECT BASED LEARNING-II

Course Objective: To motivate the students for practical application of knowledge gain

Pre-requisites: Knowledge of Mechanical engineering subjects taught.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Utilize the theoretical knowledge on actual application.
CO2	Visualize the practical application of mechanical equipments.
CO3	Able to develop new concept for various applications.

Project based learning-II should be done by the students in 4th semester for which a teacher is assigned to the student(s) under whom he/she/they will work. Minimum contact hour per week is 4 hrs.

Sub Code: **ME301A5** **Credit: 1 (L-0, T-0, P-2)**

PROJECT BASED LEARNING-III

Course Objective: To motivate the students for practical application of knowledge gain

Pre-requisites: Knowledge of Mechanical engineering subjects taught.

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Utilize the theoretical knowledge on actual application.
CO2	Visualize the practical application of mechanical equipments.
CO3	Able to develop new concept for various applications.

Project based learning-III should be done by the students in 5^{th} semester for which a teacher is assigned to the student(s) under whom he/she/they will work. Minimum contact hour per week is 4 hrs.

Sub Code: **GN_____** **Credit: 1 (L-1, T-0, P-0)**

QUANTITATIVE APTITUDE AND LOGICAL REASONING - I

Questions to be set: 05 (All Compulsory)

Course Objective: The main aim of introducing "Quantitative Aptitude & Logical Reasoning" to university students is to develop numerical skills among students and to prepare them for various examinations to enhance better job prospects. This initiative is being taken to include essential mathematical principles to build students' confidence. It is expected to expand students' knowledge and foster their logical reasoning and analytical thinking abilities.

Pre-requisites: NIL

Course Outcomes (CO): On successful completion of the course

CO	STATEMENT
CO1	Student will be able to solve variety of simple problems in the space of quantitative domain.
CO2	Students will be able to use data to determine or to deduce other facts from a set of given data of less complexity.
CO3	Students will be able to use shortcuts, tricks and techniques to solve the problems with moderate accuracy.
CO4	Students will be able to demonstrate essential skills pertaining to public speaking, resume writing and telephone etiquette.
CO5	Students will be able to demonstrate basic skills during the placement interviews

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Quantitative Aptitude**	In class	Problems on Trains, Time and Distance, Height and Distance, Time and Work, Simple Interest, Compound Interest, Profit and Loss, Partnership, Percentage, Problems on Ages, Calendar, Clocks, Average, Area, Volume and Surface Area	6	1		
Module 2: **Puzzles, Problem Solving and Analysis**	In class	Sudoku, Number Puzzles, Missing Letter Puzzles, Playing Card Puzzles, Clock Puzzles.	3	2		
Module 3: **Logical Reasoning**	In class	Number Series, Letter and Symbol series, Verbal Classification Essential Part, odd man out and visual reasoning, Analogies, Artificial Language, Matching Definitions, Making Judgements.	5	3		
Module 4: **Professional Builder**	In class	Resume Writing, Public Speaking, Extempore, Telephone etiquette.	4	4		
Module 5: **Use Cases**	In Class	Mock Interview – Hard and Soft Skills Sector: FMCG, IT, Production, Manufacturing etc.	2	5		

Text books:

1. Aggarwal, R. S. (2008). *Quantitative Aptitude*. S. Chand., ISBN: 9788121924986, 8121924987
2. Devi, S. (2005). *Puzzles to puzzle you*. Orient Paperbacks., ISBN: 8122200141, 9788122200140

Sub Code: **GN_____** **Credit: 1 (L-1, T-0, P-0)**

QUANTITATIVE APTITUDE AND LOGICAL REASONING - II

Questions to be set: 05 (All Compulsory)

Course Objective:
The key objective of this course is to strengthen the numerical skills and logical abilities & skills of university students and prepare them for various competitive exams, thereby improving their employment opportunities. This initiative aims to incorporate fundamental mathematical principles to build students' confidence. Additionally, it seeks to broaden their knowledge and foster their logical reasoning and analytical thinking skills.

Pre-requisites: NIL

Course Outcomes (CO): On successful completion of the course

CO	STATEMENT
CO1	Student will be able to solve variety of problems simple to complex in the space of quantitative domain.
CO2	Students will be able to use data to determine or to deduce other facts from a set of given data which are simple to complex.
CO3	Students will be able to use shortcuts, tricks and techniques to solve the problems with high accuracy.
CO4	Students will be able to demonstrate essential skills pertaining to business communications.
CO5	Students will be able to demonstrate advanced skills required at the time of placement interviews.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Quantitative Aptitude**	In class	Problems on Permutations and Combinations, Probability, Numbers, Problems on Numbers, Problems on HCF and LCM, Decimal Fraction, Simplification, Square Root and Cube Root, Surds and Indices, Ratio and Proportion, Chain Rule, Pipes and Cistern, Boats and Streams, Allegation and Mixtures, Logarithm, Races and Games, Stocks and Shares, Probability, True Discount, Odd man out and Series.	8	1		
Module 2: **Puzzles, Problem Solving and Analysis**	In class	Logical Connectives and Syllogisms, Data Interpretation, Cases, Venn Diagrams.	3	2		
Module 3: **Logical Reasoning**	In class	Verbal Reasoning, Logical Problems, Logical Games, Data Arrangement and Blood Relations, Analyzing Arguments, Statement and Assumption, Course of action, Statement and Conclusion, Theme Detection, Cause and Effect, Statement and Argument, Logical Deduction.	4	3		
Module 4: **Professional Builder**	In class	CV Writing, Verbal & Non Verbal Communication, Group Discussion, Netiquettes,	2	4		
Module 5: **Use Cases**	In Class	Mock Interview on Hard and Soft Skills Sector - IT, FMCG, Product, Financials, Manufacturing, Production, Construction etc.	3	5		

Text books:

1. Aggarwal, R. S. (2008). *Quantitative Aptitude*. S. Chand., ISBN: 9788121924986, 8121924987
2. Devi, S. (2005). *Puzzles to puzzle you*. Orient Paperbacks., ISBN: 8122200141, 9788122200140

MECHANICAL ENGINEERING
(Minor Specialization)

Sub Code: **ME201A8** **Credit: 4 (L-3, T-1, P-0)**

ALTERNATIVE FUELS AND LUBRICATIONS FOR ENGINES

Questions to be set: 05 (All Compulsory)

Course Objective:

4. To acquainted with the scope of different alternative fuels for IC engine.
5. To provide students with the knowledge on the properties, applications, limitations and different techniques of blending of different fuels
6. To acquainted with the use of lubrications and different lubricants in IC engine.

Pre-requisites: Industrial engineering, Production system.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the importance of alternative fuels.
CO2	Analyze the various parameters that are utilized to characterize alternative fuels and its suitability for SI engine
CO3	Analyze the various parameters that are utilized to characterize alternative fuels and its suitability for SI engine
CO4	Understand and analyze the theory of lubrications in IC engine.
CO5	Understand and analyze characteristics and suitability of different lubricants.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to alternative fuels**	In class	Introduction to alternative fuels, Need for alternative fuels - Availability of different alternative fuels for SI and CI engines. Properties of potential alternative fuels.	6	1		
	Assignment topics	Properties of potential alternative fuels				
Module 2: **Alternative fuels for SI Engines**	In class	Liquid Fuels for SI Engines, Different Techniques of utilizing alternative liquid fuels Blends, Neat form, Gaseous Fuels in SI Engines , Reformed fuels - Manufacturing, Storage and Safety, Performance and emission characteristics of alternative liquid fuels.	8	2		
	Assignment topics	Storage and Safety				
Module 3: **Alternative fuels for CI engines**	In class	Liquid Fuels in CI Engines, Different techniques for their utilization- Blends, Fuel modifications to suit CI engines, Dual fuelling, Ignition accelerators and other additives, Gaseous Fuels in CI Engines.	6	3		
	Assignment topics	Dual fuelling				
Module 4: **Theory of lubrication**	In class	Engine friction: introduction, total engine friction, effect of engine variables on friction, hydrodynamic lubrication, elasto hydrodynamic lubrication, boundary lubrication, bearing lubrication, functions of the lubrication system, introduction to design of a lubricating system.	8	4		
	Assignment topics	Elasto hydrodynamic lubrication				
Module 5: **Lubricants**	In class	Specific requirements for automotive lubricants, oxidation deterioration and degradation of lubricants, additives and additive mechanism, synthetic lubricants,	8	5		

		classification of lubricating oils, properties of lubricating oils, tests on lubricants. Grease, classification, properties.				
	Assignment topics	Synthetic lubricants				

Text books:

1. Ramadhas A S, "Alternative Fuels for Transportation", CRC Press, Taylor & Francis Group, 2010.

Reference books:

1. Thipse S S, "Alternative Fuels: Concepts, Technologies and Developments", Jaico Book Distributors, 2010.
2. Gajendra Babu M K, "Alternative Transportation Fuels: Utilization in Combustion Engines", CRC Press, Taylor & Francis Group, 2010.
3. Michael F. Hordeski, "Alternative Fuels: The Future of Hydrogen", The Fairmont Press, 2008.
4. James D. Halderman, "Hybrid and Alternative Fuel Vehicles", (2e), Prentice Hall, 2010.

Sub Code: **ME202A8** **Credit: 4 (L-3, T-1, P-0)**

AUTOMOTIVE ELECTRICAL AND ELECTRONICS SYSTEM

Questions to be set: 05 (All Compulsory)

Course Objective: Upon completion of this course, the student should be able:

6. To educate students on construction, working and testing of lead acid battery
7. To educate the students on construction and working of different types of ignition system
8. To give knowledge on construction, working of types of starter motors and Alternator and selection of starter motor.
9. To introduce basics and advancement in automobile lighting system
10. To familiarize students with electrical accessories and selection of cables, fuses and Multiplexing

Pre-requisites: Understanding of Automobile engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Explain the construction and testing of lead acid battery, charging of batteries and selection of battery for a vehicle.
CO2	Identify type of ignition system and spark timing.
CO3	Identify the type of starter motor and charging system. Selection of starter motor and alternator for a vehicle.
CO4	Understand the use of cables and lighting system for a vehicle.
CO5	Identify the auto-accessories and multiplexing cables.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Batteries and starting system**	In class	Different types of Batteries – principle, rating, testing and charging. Starter motors characteristics, capacity requirements, Drive mechanisms.	8	1		
	Assignment topics	Starter switches				
Module 2: **Charging system lighting and accessories**	In class	DC Generators and Alternators their characteristics. Control unit – cut out, electronic regulators. Vehicle interior lighting system. Wiring requirements. Lighting design. Dashboard instruments. Horn, trafficator.	8	2		
	Assignment topics	Vehicle exterior lighting system				
Module 3: **Electronic ignition and injection system**	In class	Spark plugs. Advance mechanisms. Different types of ignition systems.	6	3		
	Assignment topics	Electronic fuel injection systems, mono and multi point fuel injection system (MPFI)				
Module 4: **Sensors and microprocessors in automobiles**	In class	Basic sensor arrangements. Types of sensors – oxygen sensor, hot wire anaemometer sensor, vehicle speed sensor, detonation sensor, accelerometer sensor, crank position sensor. Microprocessor and microcomputer controlled devices in automobiles such voice warning system, travel information system, keyless entry system, automatic transmission system.	8	4		
	Assignment topics	electronic steering system.				
Module 5:	In class	Antilock braking system, air bag restraint system,	6	5		

Safety systems		voice warning system, seat belt system, road navigation system.				
	Assignment topics	Anti-theft system				

Text Books:

1. Judge. A.W., "Modern Electrical Equipment of Automobiles", Chapman & Hall, London, 1992.

Reference Books:

1. Young.A.P., & Griffiths.L., "Automobile Electrical Equipment", English Language Book Society & New Press, 1990
2. Spreadbury. F.G., "Electrical Ignition Equipment", Constable & Co Ltd., London, 1962
3. Robert N Brady "Automotive computers and Digital Instrumentation". A Reston Book, Prentice Hill, Eagle Wood Cliffs, New Jersey, 1988.

Sub Code: **ME301A8** **Credit: 4 (L-3, T-1, P-0)**

VEHICLE DYNAMICS

Questions to be set: 05 (All Compulsory)

Course Objective: Provides understanding about the application of basic mechanics principles for dynamic analysis of vehicles and how it responds to diverse in-motion conditions. Upon completion of this course, the student should be able to:

4. To understand the fundamentals of Vehicle dynamics and systems.
5. To evaluate the influence vehicle subsystems on the vehicle behavior.
6. To determine physical and design interpretations from the results.

Pre-requisites: Knowledge of Engineering Mechanics, Theory of Machine, Automobile basics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the fundamentals of Vehicle dynamics and describe various terminologies.
CO2	Explain various performance mode characteristics of the vehicle.
CO3	Analyse ride mode oscillations and compare their characteristics.
CO4	Evaluate the suspension and stability systems concepts and design the same according to requirements.
CO5	Analyse the cornering characteristics of the vehicle and evaluate yaw stability.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Earth and vehicle coordinate system. Longitudinal, lateral and vertical vehicle dynamics. Dynamic axle loads. Road loads - Aerodynamic forces and moments, viscosity effects, separation and its control; aerodynamic lift and its control, styling for minimum drag.	8	1		
	Assignment topics	Rolling resistance, ground effect, grade loads.				
Module 2: **Performance Mode**	In class	Acceleration - Free body diagram of accelerating vehicle, maximum transferable tractive force, Deceleration - free body diagram of decelerating vehicle, maximum decelerating rates, Vehicle performance.	8	2		
	Assignment topics	Acceleration gradability, Deceleration stopping distance, maximum braking force.				
Module 3: **Ride Mode**	In class	Degrees of freedom-single, two and multi degrees of freedom system, free, forced and damped vibration, model of an automobile, magnification factor, transmissibility, vibration absorbers, pitch and bounce motion, oscillation centers, active and semi active suspension, orthogonality of mode shapes,	8	3		
	Assignment topics	Modal analysis. MATLAB based Quarter car modelling and simulation.				
Module 4: **Springing System**	In class	Requirements, sprung mass and un-sprung mass, wheel hop, shimmy, wheel wobble, choice of suspension spring rate, calculation of effective spring rate. Tyres - mechanics, stability of vehicle on slope, on curve and banked road.	6	4		

	Assignment topics	Pacejakas tire model using MATLAB.				
Module 5: **Handling Mode**	In class	Vehicle control-low speed cornering and static Steering- steady-state cornering -steering factors, vehicle control parameters (under steer, neutral steer and over steer), roll steer, compliance steer, ride steer, slip angle steer, steady state handling-lateral acceleration gain, characteristic speed, yaw velocity gain, critical speed..	6	5		
	Assignment topics	Ackerman steering geometry, Effect of braking on vehicle handling, MATLAB based Assignment				

Text Books:

1. Thomas D Gillespie: Fundamentals of Vehicle Dynamics, SAE USA 1992
2. S.S. Rao: Mechanical Vibrations, Pearson Education, Delhi, 2009.

Reference Books:

1. Babu A.K.: Automobile Mechanics, Khanna Publishers, New Delhi.
2. Cole D.E,: Elementary Vehicle Dynamics, Ann Arbor, Michigan, USA, 1972.

Sub Code: **ME302A8** **Credit:4 (L-3, T-1, P-0)**

AUTOMOTIVE REPAIR AND MAINTENANCE

Questions to be set: 05 (All Compulsory)

Course Objective: The course covers the primary areas of automotive technology by teaching shop management, vehicle systems theory, and troubleshooting and repair processes. Upon completion of this course, the student should be able to:

3. Diagnose the faults that may appear in automobile.
4. Understand the use and servicing requirements of the various automobile components.

Pre-requisites: Knowledge of Automobile and its various components.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the general maintenance aspects, servicing, machines etc of a vehicle
CO2	Understand and analyze the faults developed in an engine and its remedial measure.
CO3	Understand and analyze the faults developed in transmission and driveline of a vehicle.
CO4	Analyze the faults that may develop in clutch and braking system of an automobile.
CO5	Understand and perform an examination of a vehicle's cooling, electrical, and fuel systems.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Maintenance, Workshop Practices, Safety And Tools**	In class	Maintenance – Need, importance, primary and secondary functions, policies - classification of maintenance work - Automotive service procedures – workshop operations – workshop manual - vehicle identification. Safety – Personnel, machines and equipment, vehicles, fire safety - First aid. condition checking of seals, gaskets and sealants. Scheduled maintenance services – service intervals - Towing and recovering	8	1		
	Assignment topics	Vehicle insurance - basic problem diagnosis, Basic tools – special service tools – measuring instruments.				
Module 2: **Engine And Engine Subsystem Maintenance**	In class	General Engine service- Dismantling of Engine components- Engine repair- working on the underside, front, top, ancillaries- Service of basic engine parts, cooling and lubricating system, fuel system, Intake and Exhaust system, electrical system.	6	2		
	Assignment topics	Electronic fuel injection and engine management service - fault diagnosis- servicing emission controls.				
Module 3: **Transmission And Driveline Maintenance**	In class	Clutch- general checks, adjustment and service- Dismantling, identifying, checking and reassembling transmission, transaxle- road testing- Removing and replacing propeller shaft, servicing of cross and yoke joint and constant velocity joints- Rear axle service points- removing axle shaft and bearings- servicing differential assemblies.	6	3		
	Assignment topics	fault diagnosis.				
Module 4: **Steering, Brake, Suspension,**	In class	Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake, Parking brake. Bleeding of brakes. Inspection, Maintenance and Service of Mc person strut, coil spring, leaf spring, shock absorbers.	8	4		

Wheel Maintenance		Inspection, Maintenance and Service of steering linkage, steering column, Rack and pinion steering, Recirculating ball steering service- Worm type steering, power steering system.				
	Assignment topics	Dismantling and assembly procedures. Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation.				
Module 5: **Auto Electrical And Air Conditioning Maintenance**	In class	Maintenance of batteries, starting system, charging system and body electrical -Fault diagnosis using Scan tools. Maintenance of air conditioning parts like compressor, condenser, expansion valve, evaporator - Replacement of hoses- Leak detection- AC Charging	8	5		
	Assignment topics	Fault diagnosis, Vehicle body repair like panel beating, tinkering, soldering, polishing, painting.				

Text Books:

1. Ed May: Automotive Mechanics Volume One and Two, Mc Graw Hill Publications, 2003.
2. Gilles Tim: Automotive Service Inspection Maintenance Repair, 4Th Edition, Cengage Learning.

Reference Books:

1. Bosch Automotive Handbook, Sixth Edition, 2004

Sub Code: **ME203A8** **Credit: 4 (L-3, T-1, P-0)**

COMPOSITE MATERIALS

Questions to be set: 05 (All Compulsory)

Course Objective: Composite Material will help the students to:

3. To understand the mechanical behaviour of composite materials.
4. To get an overview of the methods of manufacturing composite materials.

Pre-requisites: Basic concept of Mechanical Engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	Understand the importance of Composite Materials in various application fields of engineering and specifics of mechanical behaviour of layered composites compared to isotropic materials.
CO2	Understand the various composite fabrication methods.
CO3	Understand the effect of different orientation of fibres in composites and its mechanical characteristics.
CO4	Understand the various aspect of short fibre composite.
CO5	Understand the analysis of laminated composite materials.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to Composite Materials, Fibers**	In class	Definition, characteristics, Classification. Advanced Fibers, Glass Fibers, Carbon and Graphite Fibers, Aramid Fibers.	9	1		
	Assignment topics	Glass Fibers, Carbon and Graphite Fibers, Aramid Fibers.				
Module 2: **Fabrication of Composites**	In class	Matrix Materials, Fabrication of Composites	7	2		
	Assignment topics	Different process				
Module 3: **Behavior of Unidirectional Composites**	In class	Longitudinal behavior of Unidirectional Composites, Transverse Stiffness· and Strength, Prediction of Shear Modulus, Prediction of Poisson's Ratio, Failure Modes I, Expansion Coefficients and Transport 'Properties, Typical Unidirectional Fiber Composite Properties.	7	3		
	Assignment topics					
Module 4: **Short-Fiber Composites**	In class	Theories of Stress Transfer, Modulus and Strength of Short-Fiber Composites, Ribbon-Reinforced Composites. Stress-Strain Relations and Engineering Constants, Hooke's Law and Stiffness and Compliance Matrices,	7	4		
	Assignment topics	Numericals				
Module 5: **Analysis of Laminated Composites**	In class	Strengths of an Orthotropic Lamina, Laminate Strains, Variation of Stresses in a Laminate, Resultant Forces and Moments: Synthesis of Stiffness Matrix, Laminate Description System, Construction and Properties of Special Laminates, Determination of Laminae Stresses and Strains, Analysis of Laminates after Initial Failure, Hygrothermal Stresses in Laminates.	9	5		
	Assignment topics	Numerical				

Text books:

1. Broutman, et. al.: Analysis and Performance of Fiber Composites –WILEY

Reference books:

1. Chung et. al.: Composite Materials: Science and Applications- springer
2. Jones et. Al.: Mechanics of Composite Materials, - Tylor & Francis

Sub Code: **ME204A8** **Credit: 4 (L-3, T-1, P-0)**

TRIBOLOGY

Questions to be set: 05 (All Compulsory)

Course Objective: Design of surfaces in contact is a critical problem for mechanical engineering. Tribology is an interdisciplinary course which deals with fundamentals of surface contact, friction, wear and lubrication. Upon completion of this course, the student should be able to:

3. To understand modeling of engineering surfaces, popular surface contact theories, major modes of friction, wear, lubrication and adhesion.
4. Grasp the fundamental knowledge of the friction/lubrication mechanisms and know how to apply them to the practical engineering problem.

Pre-requisites: Knowledge of Engineering Mechanics, Theory of Machine, Automobile basics.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understanding of surface topography and know how to model a rough engineering surface.
CO2	Have an understanding about the basics of tribology related sciences and about processes in tribological system, analysis of mechanisms and forms of interaction of friction surfaces.
CO3	Understand Hertz contact and rough surface contact.
CO4	Understand the adhesion theories and analyze the effect of adhesion on friction and wear.
CO5	Apply the methods to reduce the friction for engineering surface

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Engineering Surfaces**	In class	Properties and Measurement: Measurement Methods, Surface Profilometry, Statistical Description of Roughness.	8	1		
	Assignment topics	Introduction: History, Industrial Importance.				
Module 2: **Surface Contact, Adhesion**	In class	Surface Contact: Hertz contact theory, Greenwood-Williamson model, Elastic-plastic contact. Adhesion: Basic Models, Factors influencing Adhesion.	8	2		
	Assignment topics	Effects of Adhesion.				
Module 3: **Friction, Surface Engineering**	In class	Friction: Measurement Methods, Origin of Friction, Friction Theories – adhesion and ploughing, Mechanisms, Friction of Metals, Non-metallic Materials. Surface Engineering: Surface Treatments: Microstructural and Thermochemical Treatments, Surface Coatings: Hard Facing, Vapour Deposition Processes: PVD, CVD, PECVD etc.	8	3		
	Assignment topics	Problem Solving				
Module 4: **Wear, Lubrication**	In class	Wear: Types: Adhesive, Abrasive, Corrosive, Fatigue, Minor Forms: Fretting, Erosion, Percussion, Delamination Theory, Wear Debris Analysis, Wear Testing Methods, Wear of Metals, Ceramics, Polymers.	6	4		

		Lubrication: Basic Equations for Fluid Film Lubrication. Hydrodynamic lubrication -Thrust and Journal bearings,				
	Assignment topics	Squeeze Film Bearings, Hydrostatic lubrication				
Module 5: **Lubrication, Nanotribology**	In class	Gas-Lubrication. Lubrication of rolling element bearings. Boundary lubrication – metal working lubrication. Measurement Tools: Surface Force Apparatus, Scanning Tunnelling Microscope, Atomic / Friction Force Microscope.	6	5		
	Assignment topics	solid film lubrication				

Text Books:

1. P. Sahoo: Engineering Tribology, Prentice Hall-India, New Delhi, 2009.

Reference Books:

1. B. Bhushan: Introduction to Tribology, Wiley, 2002..
2. G W Stachowiak and A W Batchelor: Engineering Tribology, Butterworth-Heinemann, 2005.
3. S.K. Basu, S.N. Sengupta, B.B. Ahuja: Fundamentals of Tribology, Prentice Hall-India, 2005.
4. B C Majumdar: Introduction to Tribology of Bearings, S Chand & Co, 2012.

Sub Code: **ME303A8** **Credit: 4 (L-3, T-1, P-0)**

DESIGN OF MECHANICAL SYSTEMS

Questions to be set: 05 (All Compulsory)

Course Objective:

5. To apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine component.
6. To give the assurance that his designs will never failure at any circumstances.
7. To apply mechanical engineering design theory to identify and quantify machine elements in the design of commonly used mechanical system.
8. To develop ability to come up with innovative ideas.

Pre-requisites: Basics of strength of materials & Material science, Elementary design.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Demonstrate the ability to design, analysis and sizing of Piston.
CO2	Demonstrate the ability of selection, sizing and analysis of connecting rods
CO3	Demonstrate the ability of selection of bearing types, and sizing and analysis of crankshaft
CO4	Demonstrate the ability of selection of gear types, sizing, analysis and automobile chasis
CO5	Demonstrate the ability of selection, sizing, design, and analysis of other mechanical components/systems

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Synthesis of Mechanisms**	In class	Mechanical design process, design factors, design of mechanical systems - Piston, Connecting rod	7	1		
	Assignment topics	Numerical		1		
Module 2: **Cams**	In class	Crankshaft- Overhung & Center type, Valve gear mechanism	7	2		
	Assignment topics	Numerical		2		
Module 3: **Dynamics of direct acting engine mechanism and governors**	In class	Single plate clutch, Passenger lift,	13	3		
	Assignment topics	Numerical		3		
Module 4: **Gyroscopic effects**	In class	Design of mechanical systems: Concrete mixer, Automobile chassis & suspension. Johnson's method of optimization.	7	4		
	Assignment topics	Numerical		4		
Module 5: **Balancing of rotating masses and reciprocating masses**	In class	Design for manufacture of cast, forged, turned, milled, drilled and ground parts, design for heat treatment, design for assembly.	12	5		
	Assignment topics	Numerical		5		

Text Books:

1. Bhandari V.B., “Design of Machine Elements”, (3e), Tata McGraw Hill Publishing Company, New Delhi, 2010

Reference Books:

1. Trikha S. N., “Machine Design Exercises”, Khanna Publishers, Delhi, 2001.
2. Patil S. P., “Mechanical System Design”, Jaico Publishing House, Mumbai, 2004.
3. George E. Dieter, “Engineering Design”, McGraw Hill Book Co., Singapore, 2000.
4. Mahadevan K. and Balaveera Reddy K., “Machine Design Data Hand Book”, (4e), CBS Publishers and distributors, New Delhi, 1987.

Sub Code: **ME304A8** **Credit: 4 (L-3, T-1, P-0)**

FATIGUE AND FRACTURE

Questions to be set: 05 (All Compulsory)

Course Objective: Understanding the mechanics of fatigue and fracture is critical for ensuring the structural integrity of load bearing components in the presence of crack-like flaws. Upon completion of this course, the student should be able to:

4. To understand the principles and applications of linear and nonlinear fracture mechanics.
5. Grasp fracture phenomena in metals and nonmetals will be explored.
6. Understand the mechanics of fatigue and fracture for ensuring the structural integrity of load bearing components in the presence of crack-like defects.

Pre-requisites: Students should have an understanding of Strength of Material and basic elements of mechanical engineering.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Identify and understand the effects of fatigue load.
CO2	Analyze the cumulative damage produced by linear elastic fracture mechanics.
CO3	Analyze fracture initiation and development, as well as the energy associated with them.
CO4	Investigate the micromechanics of fatigue strength in broken bodies to determine their strength.
CO5	Understanding the impact of mean stress on the cyclic plastic zone's size and predicting fatigue crack formation based on LEFM basics.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Linear Elastic Fracture Mechanics (LEFM) I :**	In class	Introduction and review of solid mechanics Introduction to fatigue and fracture of materials, History and Overview. stress concentration effect of flaws, Cracks as stress raisers; The Griffith energy balance, The energy release rate, Crack growth instability analysis and R curve, Stress analysis of cracks: Generalised In-plane Loading (Williams approach),Westergaard stress function.	8	1		
	Assignment topics	Effects of Cracks on Strength; Effect of Cracks on Brittle versus Ductile Behaviours				
Module 2: **Linear Elastic Fracture Mechanics II**	In class	The stress Intensity factor K, Effect of size, Principle of superposition, Weight functions, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of KIC with material; Effects of Temperature and loading rate.; Microstructural Influences on KIC; Mixed mode fracture.	8	2		
	Assignment topics	Behaviour at Crack Tips in Real Materials				
Module 3: **Elastic-Plastic Fracture Mechanics (EPFM)**	In class	Crack tip opening displacement (CTOD), The J-contour integral, J as a nonlinear energy release rate, The HRR singularity, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, Relationship between J and CTOD	8	3		
	Assignment topics	The large strain zone, Laboratory measurement of J				
Module 4:	In class	Micromechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design,fail-	6	4		

Fatigue of Materials I		safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach, Cyclic deformation and the strain-life (ε-N) approach,				
	Assignment topics	Fatigue analysis				
Module 5: **Fatigue of Materials II**	In class	Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth, Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories,	6	5		
	Assignment topics	Load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.				

Text Books:

1. T L Anderson: Fracture Mechanics: fundamentals and applications.
2. S. Suresh: Fatigue of materials, Second Edition, cambridge university press.

Reference Books:

1. J.F.Knott Butterworths: Fundamentals of Fracture Mechanics.
2. Fatemi, Fuchs and Stephens: Metal Fatigue in Engineering Stephens, John Wily.
3. F.Ellyin: Fatigue Damage, Crack Growth and Life Prediction, Chapman & Hall.
4. D. Broek: Elementary Engineering Fracture Mechanics, Kluwer Academic.

Sub Code: **ME205A8** **Credit: 4 (L-3, T-1, P-0)**

INTRODUCTION TO NANOTECHNOLOGY AND MEMS

Questions to be set: 05 (All Compulsory)

Course Objective: The course outlines the following objective:

4. To inspire the students to expect to the trends in development and synthesizing of nano systems and measuring systems to nano scale.
5. To expose the students to the evolution of Nano systems, to the various fabrication techniques
6. Also to impart knowledge to the students about nano materials and MEMS

Pre-requisites: Basic understanding of Material science.

Course Outcomes (CO): On Successful Completion of the course students will be able:

CO	STATEMENT
CO1	To get the basic knowledge of the evolution of Nano technology.
CO2	To impart knowledge to the students about nano materials and Nano composites
CO3	To get knowledge about various characterization techniques for the measurement of nanomaterials
CO4	To understand nano scale manufacturing
CO5	The students are expected to understand MEMS.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Nanotechnology Basics**	In class	Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration.	6	1		
	Assignment topics	surface effects on the properties of Nanomaterials, Advantages of Nanomaterials				
Module 2: **Science of Nano Materials:**	In class	Classification of nano structures - effect of the nanometer length scale effects of nano scale dimensions on various properties - structural, thermal, chemical, mechanical, magnetic, optical and electronic properties - effect of nanoscale dimensions on biological systems. Fabrication methods - Top down processes - bottom up process.	8	2, 4		
	Assignment topics					
Module 3: **Nano scale manufacturing:**	In class	Nanomanipulation, Nanolithography - An introduction to tribology and its industrial applications - Nanoscale Materials and Structure, Nanocomposites,	6	2, 4		
	Assignment topics	Application of nanocomposites				
Module 4: **Characterization of Nanomaterials**	In class	Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM), Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Nano indentation, Nano scratch, Infra-red spectroscopy (IR), Raman Spectroscopy, Photoluminescence (PL), X-ray photoelectron spectroscopy (XPS)	12	3		
	Assignment topics	Scanning Tunneling Microscopy (STM), X-ray diffraction, powder diffraction, lattice parameters,				

		structure analyses, strain analyses, phase identification, particle size analyses using - Scherer`s formula -				
Module 5: **Introduction to MEMS and Micro Systems**	In class	. MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Microfabrication, Microsystems and Microelectronics, The Multidisciplinary Nature of Microsystem, Design and Manufacture, Microsystems and Miniaturization,	6	5		
	Assignment topics	Applications of Microsystems in the Automotive Industry, Applications of Microsystems in Other Industries				

Text Books:

1. Mark Ratner & Daniel Ratner, Nano Technology, Pearson Education,2003
2. "Introduction to Nanoscience", G.L. Hornyak, J. Dutta, H.F. Tibbals, A.K. Rao, CRC Press, ISBN: 978-1-4200-4805-6.

Reference books:

1. Introduction to Nanoscience", S.M.Lindsay, Oxford ISBN 978-019-954421-9 (2010). Availableon-line from the library.

Sub Code: **ME206A8** **Credit: 4 (L-3, T-1, P-0)**

FLEXIBLE MANUFACTURING SYSTEM

Questions to be set: 05 (All Compulsory)

Course Objective: To facilitate the:

7. Understanding of the concepts and applications of flexible manufacturing systems.
8. Understanding of planning, scheduling, and control of flexible manufacturing systems.
9. Knowledge of computer control in flexible manufacturing systems.
10. Understanding of computer software for flexible manufacturing systems.
11. Understanding of flexible manufacturing systems simulation.
12. Understanding of databases in flexible manufacturing systems.

Pre-requisites: Basic knowledge of manufacturing, management, and automation.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Understand the concepts and applications of flexible manufacturing systems.
CO2	Understand planning, scheduling, and control of flexible manufacturing systems.
CO3	Gain knowledge of computer control in flexible manufacturing systems.
CO4	Understand computer software for flexible manufacturing systems.
CO5	Understand flexible manufacturing systems simulation and database.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Introduction**	In class	Introduction to FMS, development of manufacturing systems, benefits, major elements, types of flexibility.	9	1		
	Assignment topics	Learning more about the concept of the FMS from various web-sites. Writing of a 1 page report on the findings.				
Module 2: **Planning, scheduling, and control of flexible manufacturing systems**	In class	FMS application and flexibility – single product, single batch, n-batch scheduling problem, knowledge based scheduling system.	9	2		
	Assignment topics	Numerical Examples				
Module 3: **Computer control for flexible manufacturing systems**	In class	Introduction, composition of FMS, hierarchy of computer control, computer control of work center and assembly lines, FMS supervisory computer control	7	3		
	Assignment topics	Concept of TaKT Time, Analog and Digital Computer				
Module 4: **Computer software for flexible manufacturing systems**	In class	Types of software specification and selection – trends.	4	4		
	Assignment topics	Recent advancements in FMS software				
Module 5: **FMS simulation and database**	In class	Application of simulation, model of FMS, simulation software, limitation, manufacturing data systems, data flow, FMS database systems, planning for FMS database.	7	5		

	Assignment topics	Case study example of databases in FMS				

Text Books:

1. Jha, N.K. “Handbook of flexible manufacturing systems”, Academic Press Inc., 1991.

Reference Books:

1. Radhakrishnan P. and Subramanyan S., “CAD/CAM/CIM”, Wiley Eastern Ltd., New Age International Ltd., 1994.
2. Raouf, A. and Ben-Daya, M., Editors, “Flexible manufacturing systems: recent development”, Elsevier Science, 1995.
3. Groover M.P., “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt., New Delhi, 1996.
4. Kalpakjian, “Manufacturing Engineering and Technology”, Addison-Wesley Publishing Co., 1995.
5. Taiichi Ohno, “Toyota Production System: Beyond large-scale Production”, Productivity Press (India) Pvt. Ltd. 1992.

Sub Code: **ME305A8** **Credit: 4 (L-3, T-1, P-0)**

MECHATRONICS

Questions to be set: 05 (All Compulsory)

Course Objective:

4. Understand the Mechatronics system.
5. Know the CNC programming.
6. Understand the control systems

Pre-requisites: Basics of mechanics and mechanics of materials, electronic circuits, mathematics, programming, analysis and design.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Identify key elements of mechatronics system and its representation in terms of block diagram.
CO2	Differentiate the various N/C machines.
CO3	Design and develop a prototype using CNC lathe and milling machines.
CO4	Interlink the mechanical and electrical system.
CO5	Apply the concepts of computer process interfacing.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction to Mechatronic: Numerical Control of Machine Tools**	In class	Definition, Basic Concept and elements of Mechatronic system, need and benefit of mechatronic system. Need for N/C machine tools, Basic Components of N/C system, Design Consideration of N/C Machine tools, N/C motion control system.	6	1,2		
	Assignment topics	Application of N/C machines.				
Module 2: **Computer Control of N/C tools: Manual ISO Part Programming**	In class	Problems with N/C machines, Computer Numerical Control, Direct Numerical Control, Adaptive Control machining system, Flexible Manufacturing System, N/C coordinate systems, Preparatory Functions and Miscellaneous Functions, Examples of part programming with CNC Lathe and Milling Machine.	8	1,2,3		
	Assignment topics	Part Program.				
Module 3: **Feedback devices and Counting Devices**	In class	Logic Gates, Encoder, Resolver, Inductosyn, Tachometer. Flip Flops, Counters and Decoders.	7	4		
	Assignment topics	Simple logic assignments.				
Module 4: **Controller: Drives**	In class	Basic concept and elements of Microprocessor, Microcomputer and Assembly Languages. Concept of Hydraulic System, Stepping Motor.	7	4		
	Assignment topics	Application.				
Module 5: **Computer–**	In class	Manufacturing process data, System Interface hardware devices-Transducer, Sensors, Programmable Logic controller (PLC).	8	5		

Process Interfacing	Assignment topics	PLC based programming.				

Text Books:

1. HMT Handbook: Mechatronics, Tata McGraw Hill Publication, 1997.
2. Yorem Koren: Computer Control of Manufacturing Systems, McGraw Hill Book Company.
3. Zimmer & Groover: Computer Aided Design and Manufacture, Prentice Hall of India Pvt. Ltd.
4. Mehta. V. K.: Principles of Electronics, S.Chand & Company Limited.

Reference Books:

1. Mikell P. Groover: Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India Pvt. Ltd.
2. Ramesh S. Gaonkar: Microprocessor, Architecture, Programming and Application, Penram International Publshing (India).

Sub Code: **ME306A8** **Credit: 4 (L-3, T-1, P-0)**

ROBOT KINEMATICS AND DYNAMICS

Questions to be set: 05 (All Compulsory)

Course Objective:

5. To develop the student's knowledge in various robot structures and their workspace.
6. To develop student's skills in performing spatial transformations associated with rigid body motions.
7. To develop student's skills in perform kinematics analysis of robot systems.
8. To provide the student with some knowledge and analysis skills associated with trajectory planning.

Pre-requisites: Dynamics, Computer Programming and Problem Solving.

Course Outcomes (CO): On Successful Completion of the course students will be able to:

CO	STATEMENT
CO1	Demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics.
CO2	Demonstrate an ability to apply spatial transformation to obtain forward kinematics equation of robot manipulators.
CO3	Demonstrate an ability to solve inverse kinematics of simple robot manipulators.
CO4	Demonstrate an ability to generate joint trajectory for motion planning.
CO5	Gain some knowledge and skills associated with robot control.

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Introduction**	In class	Specifications of Robots- Classifications of robots – Work envelope - Flexible automation versus Robotic technology – Applications of Robots.	5	1		
	Assignment topics	NA				
Module 2: **Direct & Inverse Kinematics**	In class	Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axis robots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two Axis Three axis, Four axis and Five axis robots.	8	2		
	Assignment topics	Problems on kinematic analysis of robot				
Module 3: **Workspace Analysis**	In class	Workspace analysis of Four axis, five axis and Six axis robots, Perspective transformation, structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures.	7	3		
	Assignment topics	Problems workspace analysis				
Module 4: **Differential Motion and Statics**	In class	The tool Configuration jacobian matrix for three axis and, four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.	8	4		
	Assignment topics					

Module 5: **Dynamic Analysis and Forces And Trajectory Planning**	In class	Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot. Trajectory planning, pick and place operations, Continuous path motion, Interpolated motion, Straight line motion.	8	4,5		
	Assignment topics					

Text Books:

1. Robert J. Schilling, ―Fundamentals of Robotics Analysis and Control‖, PHI Learning, 2009.
2. Niku S B, ―Introduction to Robotics, Analysis, Systems, Applications‖, Prentice Hall, 2001.

Reference Books:

1. John J Craig, ―Introduction to Robotics‖, Pearson, 2009.
2. Deb S R and Deb S, ―Robotics Technology and Flexible Automation‖, Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S K, ―Introduction to Robotics‖, Tata McGraw Hill Education Pvt. Ltd, 2010.

Sub Code: **ME207A8** **Credit: 4 (L-4, T-0, P-0)**

Foundations of EV & Hybrid Vehicles

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To provide the performance characteristics of electric and hybrid vehicles.
2. To explain the environmental impact and sustainability considerations associated with electric and hybrid vehicles
3. To understand the design and operation of charging infrastructure, as well as power management systems in electric and hybrid vehicles.
4. To teach the learners on how to integrate various components at the system level to ensure efficient and reliable operation of electric vehicles

Pre-requisites: Fundamentals of Maths and Science

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Apply the fundamental principles of Science and Engineering, and study the performance characteristics of electric and hybrid vehicles.
CO2	Relate the environmental impact, sustainability aspects, and policy/regulatory dynamics of electric and hybrid vehicles.
CO3	Demonstrate knowledge of Electrical power, Control System and analysis.
CO4	Demonstrate knowledge of charging infrastructure, power management systems, and emerging trends in the electric and hybrid vehicle field.
CO5	Illustrate the component level integration of Electric Vehicles.

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Principles for Electric Vehicles**	In class	EV Industry, EV Technology and Automotive Revolution, Electrical Engineering for EV, Battery Technology	9	1		
	Assignment topics					
Module 2: **Control system for Electric Vehicles**	In class	Motor and Controller Systems, EV Numerical Calculations, EV Charging Infrastructure, Practical session - Well-to-wheel analysis of EV architecture	9	2,3		
	Assignment topics					
Module 3: **Essentials for Electric Vehicles**	In class	Electrical Requirement, Power Distribution Specifications, Electronic Control System, Practical session - EV connection and system analysis	9	3		
	Assignment topics					
Module 4: **Types of components in Electric Vehicles**	In class	EV Standards and Classifications, Selection for Electrical and Electronic Components, Practical session - EV hardware components	9	4		
	Assignment topics					
Module 5: **Principles for Hybrid Vehicles**	In class	Introduction to Hybrid Vehicles, Battery Chemistry, Efficiency, Definition and Parameters for Hybrid Systems, Electric Motors, Generators and Power	9	3,2		

		Electronics for Hybrid Systems, Control Systems, Hybrid Electric Vehicle Operation, Practical session - Numerical study on powertrain sizing of HEV				
	Assignment topics					

Text Book:

1. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley, 2nd ed, 2012.ISBN-13: 9781119942733
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, Routledge, 3rd Ed, 2021.ISBN-13: 9780367693930
3. Muhammad Ehsani, Mehrdad Ehsani, and Ali Emadi, Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiatives, Springer, 2015.ISBN-13: 9783319360966
4. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 1st Ed, 2014.ISBN-13: 9781466597693
5. "Introduction to Electric Vehicles" – NPTEL course offered by IIT Delhi. Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview.

Reference books:

1. "Electric Vehicle Technology" by Anant V. Kulkarni
2. "Power Electronics and Electric Drives for Traction Applications" by Gonzalo Abad and Sergio Busquets-Monge
3. "Electric Vehicle Integration into Modern Power Networks" by Yasser Abdel-Rady Ibrahim
4. "Electric Vehicles: Prospects and Challenges" edited by Majid Nayeripour, Subhas Chandra Mukhopadhyay, and Vijay Kumar Devabhaktuni
5. "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives" by Christopher Mi

Sub Code: **ME208A8** **Credit: 4 (L-4, T-0, P-0)**

Automotive Mechanics for Electric Vehicles

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To familiarise with vehicle dynamics and the elements involved in automotive engineering
2. To utilize software-based sketching and SolidWorks tools to create detailed modular-level designs of electric vehicles, covering chassis, frame, electrical components, battery packs, motors, drive trains, wheels, and tires
3. To provide the modelling skills to system-level design, incorporating interactions between components and assessing system-level behaviour and performance.
4. To compare and contrast different EV standards and classifications, including safety, environmental and performance standards
5. To conduct system-level analysis of electric vehicle performance, simulating ride, handling, stability, and rollover events, and optimizing vehicle designs using MSC Adams software

Pre-requisites: Basics of Mechanical/Automobile Engineering

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Interpret the fundamentals of vehicle dynamics
CO2	Model Electric vehicle at modular levels
CO3	Model Electric vehicle at System level
CO4	Analysing modular level behaviour of Electric vehicles
CO5	Analysing system level behaviour of Electric vehicles

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Automotive Engineering & Vehicle Dynamics**	In class	• Vehicle Dynamics Fundamentals • Tire Mechanics and Dynamics • Suspension Systems, Braking Systems • Aerodynamics, Powertrain Systems • Vehicle Stability Control, Vehicle Safety • Vehicle Dynamics Simulation • Electric and Hybrid Vehicle Dynamics • **Practical session** - EV Dynamics & calculations	9	1		
	Assignment topics					
Module 2: **Sketching for Automotive EV Design [Software-based]**	In class	• Introduction to Automotive Sketching Software • Overview of Vehicle Design Process and Automotive Sketching • Basic Sketching Techniques and Tools in the Software • Sketching Car Exteriors, Interiors and Details • Creating Different Views and Angles of the Vehicle • Rendering and Presenting the Final Sketches • Understanding Proportions, Perspectives and Shapes in Automotive Sketching	9	2		

		• Creating Sketches for Different Vehicle Types (Sedans, SUVs, and Trucks) • Tips and Tricks for Automotive Sketching in the Software				
	Assignment topics					
Module 3: **Advanced EV Modelling Using SolidWorks Tool [Software-based]**	In class	• Introduction to EV Technology and Its Benefits • Basic Vehicle Design Principles • Design and Modelling of Chassis and Frame, Suspension Systems • Design and Modelling of Braking and Steering Systems • Design and Modelling of Electrical Components for EVs • Battery Pack Design and Modelling for 2, 3 and 4 Wheelers • Motor and Drivetrain Design and Modelling for 2, 3 and 4 Wheelers • Design and Modelling of Wheels and Tires for 2, 3 and 4 Wheelers • Testing and Simulation of Vehicle Performance Using Solid Works • Design for Manufacturability and Assembly Considerations • Sustainability and Environmental Impact Considerations in EV Design • **Practical session** - EV hardware components walkthrough	9	3		
	Assignment topics					
Module 4: **Multibody Dynamics with MSC Adams [Software-based]**	In class	• Introduction to MSC Adams Software and Its Capabilities • Setting Up the Modelling Environment in MSC Adams • Multi-body Dynamics Principles and Application to Vehicle Systems Modelling • Vehicle Suspension Systems Modelling, Vehicle Steering Systems Modelling • Vehicle Braking Systems Modelling • **Practical session** - EV Component design & modeling	9	4		
	Assignment topics					
Module 5: **EV Analysis with MSC Adams (Software-based)**	In class	• Tire Force and Characteristics Modelling • Vehicle Dynamics Analysis Including Simulating Ride and Handling, Vehicle Stability and Rollover Events • Optimisation Techniques for Vehicle Designs Using MSC Adams • Integration of MSC Adams Models with Other Software Tools for System-level Simulations and Analysis	9	5		

		• **Practical session** - EV body design analysis				
	Assignment topics					

Text Book:

1. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley, 2nd ed, 2012.ISBN-13: 9781119942733
2. Du, H., Cao, D., & Zhang, H. (n.d.). Modeling, Dynamics, and Control of Electrified Vehicles. Woodhead Publishing, 2017.ISBN-13: 9780128127865
3. Zaman, N.,. Automotive Electronics Design Fundamentals. Springer, 2015. ISBN-13: 9783319359793
4. Gianfranco Pistoia. Electric & Hybrid Vehicles, Elsevier, 1st ed, 2010.ISBN-13: 9781032556796
5. Chau, K. T. Electric Vehicle Machines and Drives: Design, Analysis and Application. John Wiley and Sons, Inc., 2015. ISBN-13: 9781118752524
6. Ehsani, Mehrdad. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. CRC, 2019. ISBN-13: 9780367137465
7. Hughes, Austin. Electric Motors and Drives. Newnes (an Imprint of Butterworth-Heinemann Ltd), 2019. ISBN-13: 9780081026151

Reference books:

1. Hybrid electric Vehicles, Principles and Applications- Chris Ni- WILEY Publications

E Books / MOOCs/ NPTEL:

1. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview

Sub Code: **ME307A8** **Credit: 4 (L-4, T-0, P-0)**

EV Mechanical Design, Development & Analysis

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To explain the basic syntax, variables, commands, M-files, types, operators, decision-making, loops, vectors, matrices, arrays, etc. and programming EV systems in MATLAB
2. To elucidate MATLAB features and Simulink for developing and simulating Electric Vehicle (EV) systems, including modeling EV units, and configuring vehicle components.
3. To utilize MATLAB for modeling electric components, such as DC and induction motors, multi-level inverters, battery chargers, and management systems, ensuring accurate representation in simulation.
4. To explain models of Battery Management Systems (BMS) using MATLAB, incorporating aspects like Li-ion battery pack modeling, DC-DC converters, and motor controller design.
5. To conduct in-depth analysis of Electric Vehicle (EV) powertrain components, including thermal management, using MATLAB and complementary tools like SolidWorks and ANSYS

Pre-requisites: Basics of Electronics/Electrical, basics of programming language

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Illustrate the fundamentals of MATLAB programming
CO2	Relate the MATLAB features for Electric Vehicle Design
CO3	Model Electric components of Electric Vehicle
CO4	Experiment with Battery Management System
CO5	Analyze an EV powertrain system model

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Essentials for Designing & simulation in MATLAB [Software-based]**	In class	• Overview and Environment • Basic Syntax, Variables and Commands • Commands, M-files, and Types • Operators, Decision Making and Loops • Vectors, Matrix, and Arrays • Colon Notation and Numbers • Strings and Functions • Numbers, Plotting and Graphics • Algebra, Calculus, Differential, and Integration • Polynomials and Transforms	9	1		
	Assignment topics					
Module 2: **Programming and Simulation MATLAB [Software-based]**	In class	• Programming EV systems in MATLAB • Simulink and Fitting • Developing SIMULINK Models for Vehicle Units • Advisor and QSS Toolbox • QSS-based Vehicle Control **Practical session** - EV architecture modeling	9	2		
	Assignment topics					
Module 3:	In class	• DC Motor Characteristics • Induction Motor Characteristics	9	3		

Electrical Drives & Mechanical structure interfacing Using MATLAB [Software-based]		• Simulink Model to Calculate Vehicle Configuration • Multi-level Inverter Design and Modelling • **Practical session -** EV Vehicle analysis				
	Assignment topics					
Module 4: **Battery Chargers & Management system modelling Using MATLAB [Software-based]**	In class	• Solar PV-based Charger • DC-DC Converter • Motor Controller Design • Battery Management System Modelling • Modelling of Li-ion Battery Pack Using MATLAB	9	4		
	Assignment topics					
Module 5: **EV Advanced Powertrain Development**	In class	• Introduction to EV Powertrain • Overview, Architecture and Components of EV Powertrain • Thermal Management of EV Powertrain • Modelling and Simulation of EV Powertrain Components in MATLAB • Modelling and Analysis of EV Powertrain Components in SolidWorks • Analysis of EV Powertrain Components in ANSYS • Case Study on Powertrain of Existing Models **Practical session -** EV powertrain complete developing	9	5		
	Assignment topics					

Text Book:

1. William J. Palm III, MATLAB for Engineering Applications, McGraw-Hill, 5th Ed, 2018.ISBN-13: 9781260084719
2. R.B. Choudary I K, Introduction to ANSYS 16.0, International Publishing House Pvt. Ltd, 2nd Ed, 2017.ISBN-13: 9789385909108
3. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 1st Ed, 2014.ISBN-13: 9781466597693
4. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 3rd Ed, 2021.ISBN-13: 9780367693930
5. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview

Reference books:

1. "Advanced Electric Drive Vehicles" by Ali Emadi Publisher: CRC Press ISBN: 978-1439815679
2. "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain Publisher: CRC Press ISBN: 978-1466571260
3. "Electric Vehicle Technology" by H. T. El-Shatter and M. E. El-Shatter Publisher: Artech House ISBN: 978-1596932326

Sub Code: **ME308A8** **Credit: 4 (L-4, T-0, P-0)**

EV Product Development, Homologation & Hydrogen

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To guide in comprehending the intricacies of Electric Vehicle (EV) regulations and standards, emphasizing categories, compliance procedures, and homologation processes.
2. To instruct and support learners in navigating the EV certification journey, encompassing the various testing protocols, adherence to standards, and the acquisition of necessary approvals.
3. To provide practical training on the complete product development life cycle for Electric Vehicles, including segment selection, design planning, validation, competitor analysis, and feasibility assessments.
4. To explain the foundational principles of hydrogen-based technology, covering essential hydrogen properties, fuel cell techniques, systems, and safety protocols.
5. To explain the construction and integration of hydrogen fuel cells into hybrid electric vehicles.

Pre-requisites: Basics of design, manufacturing and product development

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Interpret the various steps involved in the regulations and standards of Electric Vehicle
CO2	Demonstrate the certification process of EV
CO3	Experiment with the EV Product Development cycle
CO4	Illustrate the principles of Fuel cells
CO5	Organize the fuel-cell based Hybrid vehicle construction

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **EV Design, Manufacturing & Management**	In class	• Introduction to EV (2W, 3W & 4W) Market and Opportunities • Electric Vehicle Design Procedure and ICE Model • Introduction to EV Management (Categories, Regulations and Standards) • EV Homologation and Testing • FAME India and Manufacturing Guidelines	9	1		
	Assignment topics					
Module 2: **EV Testing, Certification & Market analysis**	In class	• EV Certification Process • EV Charging, Electric Vehicles and Retrofitting • Motor Technology and EV Motor Market Analysis • EV Categories and Proposed Changes, EV Retrofitting Business • Battery Technology in EV, EV Battery Market Analysis • **Practical session** - Conducting a market analysis of the EV industry	9	2		
	Assignment topics					
Module 3:	In class	• Introduction to Product Development Plan	9	3		

EV R&D Product Development		• Segment Selection • Product Design Plan • Product Validation Plan • Vehicle Dynamics Selection • Product Design Validation • Product Specification - Competitor Analysis • Selection of Off-the-Shelf Parts • Development Methods • Product Development Plan • Unit Economics, Design Feasibility • Design for Manufacturing, DFMEA and PFMEA • Business Plan, Product Launch • POC/MVP/Working Prototype • **Practical session** – Using the market research to develop a business plan for an EV manufacturer				
	Assignment topics					
Module 4: **Hydrogen Fuel Cells**	In class	• Introduction to Future Mobility • Why Hydrogen-based Technology • Essentials of Hydrogen • How Does Hydrogen Compare to Hydrocarbon Fuels in Terms of Energy, Flammability and Safety • Hydrogen Fuel Cells, Use of Hydrogen in IC Engines • Hydrogen Fuel Cell Techniques and Systems • Fuel Cell Engine Safety and Maintenance	9	4		
	Assignment topics					
Module 5: **Hybrid Vehicles & Fuel Cells**	In class	• Fuel Cell Hybrid Electric Vehicle Acts, Codes, Regulations and Guidelines • Maintenance and Fuelling Facility Requirements • Fuel Cells in Hybrid Electric Vehicles and Pure Electric Vehicles • Auxiliary Power Generation Using Hydrogen • Types of Fuel Cells and Techniques Used • Fuel Stack Module Construction • Fuel Cell Performance, Characteristics, Polarisation, Stoichiometry Effects, Temperature and Pressure Effects • **Practical session** – Study on Hydrogen fuel cell with MATLAB/SIMULINK	9	5		
	Assignment topics					

Text Book:

1. Beate Müller, and Gereon Meyer. Electric Vehicle Systems Architecture and Standardization Needs. Springer, 25 Feb. 2015.ISBN-13: 9783319360966

2. Detlef Stolten, and Bernd Emonts. 18th World Hydrogen Energy Conference 2010 – WHEC 2010 Proceedings Speeches and Plenary Talks. Forschungszentrum Jülich, 2012.ISBN-13: 9783893366583
3. Fijalkowski, B T. Automotive Mechatronics: Operational and Practical Issues. Springer Science & Business Media, 25 Nov. 2010.ISBN-13: 9789400704084
4. Lachmayer, Roland, et al. Innovative Product Development by Additive Manufacturing 2022. Springer Nature, 8 Apr. 2023.ISBN-13: 9783031272608
5. Michael H. Westbrook, The Electric Car: Development and Future of Battery, Hybrid and Fuel-Cell Cars (Iee Power & Energy Series, 38), ISBN 2001.9780852960134
6. ÖchsnerAndreas, and Springerlink (Online Service. Engineering Applications for New Materials and Technologies. Cham, Springer International Publishing, 2018.ISBN-13: 9783319891972
7. Weber, Julian. Automotive Development Processes. Springer Science & Business Media, 22 June 2009.ISBN-13: 9783642012525
8. Wood, David L. Impacting Rapid Hydrogen Fuel Cell Electric Vehicle (FCEV) Commercialization : System Cost Reduction and Subcomponent Performance Enhancement. Warrendale, Sae International, Cop, 2016.ISBN-13: 9780768082562

Reference books:

1. Electric and Hybrid Vehicles- Tom Denton, Routledge Publishers-ISBN 9780367273231
2. Hybrid electric Vehicles, Principles and Applications- Chris Ni- WILEY Publications

E Books / MOOCs/ NPTEL:

1. "Electric Vehicles and Mobility" - offered by Delft University of Technology on edX
   Link: https://www.edx.org/professional-certificate/electric-vehicles-and-mobility
2. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview

Sub Code: **ME407A8** **Credit: 4 (L-4, T-0, P-0)**

EV FEA Analysis

Questions to be set: 05 (All Compulsory)

Course Objective:

1. To explain how to effectively use ABAQUS and ANSYS software for advanced simulations in Electric Vehicle (EV) engineering
2. To impart practical skills in preparing models for analysis using HyperMesh, including tasks like geometry cleanup, mesh creation, and enhancing element quality for Finite Element Analysis (FEA)
3. To conduct detailed structural analyses on EV components, assessing stress, strain, and thermal effects, ensuring structural integrity and safety
4. To perform Computational Fluid Dynamics (CFD) techniques for analyzing battery thermal management, vibration, fatigue, and external cooling mechanisms in Electric Vehicles
5. To design and analyze EV structures, with a focus on ensuring the safety and integrity of battery packs, including vulnerability analysis and structural integrity assessments

Pre-requisites: Basics of Design and Finite Element Methods

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Model the structure of EV using ABAQUS & ANSYS
CO2	Inspect the structural models of EV
CO3	Analyze the structural characteristics of components using FEA
CO4	Categorize Mechanical & electrical properties of materials and Computational FD of EV system
CO5	Examine the transient analysis of EV

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **EV Design and Structural Analysis with Altair HyperMesh**	In class	• Theory of FEA/CAE • Introduction to HyperMesh • Creating and Modifying Geometry • Geometry Clean-up and Defeature • Introduction to 2D Meshing • Introduction to 3D Meshing • Element Quality • Mesh Edit • Introduction to Plastic Meshing • Introduction to 1D Meshing • Modal Analysis • Linear Static Analysis • Buckling Analysis • Connectors • **Practical session** - Optimization techniques using HyperMesh	9	1		
	Assignment topics					
Module 2: **ABAQUS in EV Engineering [Software-based]**	In class	• Introduction to Abaqus Software • Fundamentals of FEA-Stress • About Abaqus Software-Features • Applications of Abaqus Software in Different Industries	9	2		

		• Simple Modelling in Abaqus Software • Create Material and Create Assembly • Create Steps, Loads, Boundary Conditions • Generate Mesh, Result Visualization • **Practical session** - Multiphysics analysis using Abaqus				
	Assignment topics					
Module 3: **Finite element Analysis of EV structural components [Software-based]**	In class	• One Dimensional Analysis • Linear Static Analysis and Linear Buckling Analysis • Heat Transfer Analysis • Non-linear Analysis • Dynamic Simulation-Modal Analysis • Impact Analysis • Time-Dependent Load Analysis	9	3		
	Assignment topics					
Module 4: **ANSYS in EV Engineering [Software-based]**	In class	• Basics of Finite-Element Analysis (FEA) along with ANSYS Tool and Software Interface • Essential Mechanical and Electrical Properties of Materials • Various Case Studies on ANSYS Mechanical • Basics of Computational Fluid Dynamics (CFD) • Various Case Studies on ANSYS Fluent • **Practical session** – FEA analysis using ANSYS	9	4		
	Assignment topics					
Module 5: **Dynamic Simulation and Transient Analysis [Software-based]**	In class	• Simulation of Battery Thermal Management in Electric Vehicle • Vibration and Fatigue Analysis of Battery Pack • Simulation of Structural Integrity for Motor Mount • Thermal Analysis of Liquid-Cooled Radiator • CFD Study of External Cooling Mechanism for Battery Pack • **Practical session** - Vulnerability analysis	9	5		
	Assignment topics					

Text Book:

1. Gokhale, Nitin S. Practical Finite Element Analysis. FINITE TO INFINITE, 2008.ISBN-13: 9788190619516
2. Mohamed Amine Fakhfakh. Modeling and Simulation for Electric Vehicle Applications. BoD – Books on Demand, 5 Oct. 2016.ISBN-13: 9789535126362
3. Narayana, Lakshmi, et al. Advances in Automation, Signal Processing, Instrumentation, and Control. Springer Nature, 4 Mar. 2021. ISBN 9789811582202

4. P Seshu. Textbook of Finite Element Analysis. New Delhi, Prentice-Hall Of India, 2010.ISBN-13: 9788120323155
5. Turner, John. Progress in Modeling and Simulation of Batteries. SAE International, 15 June 2016.ISBN-13: 9780768082821
6. Y Nakasone, et al. Engineering Analysis with ANSYS Software. Amsterdam, Butterworth-Heinemann, 2018.ISBN-13: 9780081021644

Reference books:

1. "Introduction to the ANSYS Parametric Design Language (APDL): A Guide to the ANSYS Parametric Design Language" by Paul D. Kurowski Publisher: SDC Publications ISBN: 978-1585039141
2. "Abaqus Analysis User's Guide" by Dassault Systems Publisher: Dassault Systems ISBN: N/A (Available as part of the Abaqus documentation)
3. "A First Course in Computational Fluid Dynamics" by Patrick J. Roache Publisher: Society for Industrial and Applied Mathematics (SIAM) ISBN: 978-0898714822
4. "Introduction to Computational Fluid Dynamics: Development, Application and Analysis" by Atul Sharma Publisher: CRC Press ISBN: 978-0367333620

E Books / MOOCs/ NPTEL:

1. "Electric and Hybrid Vehicles: Design and Analysis" by Omar Faruque
2. "Introduction to Electric Vehicles" - offered by Indian Institute of Technology Delhi on NPTEL Link: https://onlinecourses.nptel.ac.in/noc21_ee05/preview
3. "Introduction to Electric Vehicles" by Gregory L. Reed and Robert Hebner

Sub Code: **ME408A8** **Credit: 4 (L-4, T-0, P-0)**

EV Data Analytics & Cyber Security

Questions to be set: 05 (All Compulsory)

Course Objective:

1. Understand the importance of cybersecurity in the automotive industry and its impact on vehicle systems.
2. Analyse automotive megatrends and their implications for cybersecurity in vehicle development processes.
3. Gain knowledge of the data analytics pipeline and its application in the automotive industry, in the context of electric vehicles (EVs).
4. Apply statistical analysis techniques to EV data, including collection, pre-processing, regression, classification, and clustering, for insights and decision-making.
5. Explore the role of data analytics in automotive system data collection, focusing on sensors, and investigate predictive maintenance techniques.

Pre-requisites: Basics of Data Analytics

Course Outcomes (CO): On Successful Completion of the course students will:

CO	STATEMENT
CO1	Infer the principles of cyber security in Automotive products
CO2	Interpret the mobility services in Autonomous vehicles
CO3	Select and use Data acquisition techniques
CO4	Test for Fault, RUL in automotive systems
CO5	Utilize Bigdata analytics for Automotive data

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: **Cyber Security for Automotive Vehicle Systems**	In class	• Mobile Apps for Connected Car • Car Hailing and Ride Sharing • Connected Parking and Automated Valet Parking • ADAS and Autonomous Driving	9	1		
	Assignment topics					
Module 2: **Advanced Mobility Services**	In class	• Mobile Apps for Connected Car • Car Hailing and Ride Sharing • Connected Parking and Automated Valet Parking • ADAS and Autonomous Driving	9	2		
	Assignment topics					
Module 3: **Data Analytics for EV and Automotive Systems**	In class	• Introduction to Data Analytics and Its Application in the Automotive Industry • Understanding of the Data Analytics Pipeline • Overview of Data Analytics, Its Tools, and Techniques • EV Data Collection and Analysis • Sensors and Data Collection in EVs • Data Acquisition and Pre-processing • Statistical Analysis of EV Data	9	3		

		• Practical session - Conducting a vulnerability assessment on an in-vehicle network, and developing a report on the findings with recommendations for mitigations				
	Assignment topics					
Module 4: **Automotive System Data Collection and Analysis**	In class	• Automotive Systems (such as Engines, Transmissions, Brakes, etc.) • Data Acquisition and Pre-processing • Statistical Analysis of Automotive System Data • Regression, Classification and Clustering • Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) • Predictive Maintenance Techniques in Automotive Systems • Fault Detection and Diagnosis • Remaining Useful Life (RUL) Prediction • **Practical session** - Developing predictive maintenance models for automotive systems	9	4		
	Assignment topics					
Module 5: **Introduction to Big Data Platforms**	In class	• Introduction to Big Data Platforms and Tools (such as Hadoop, Spark, and Kafka) • How to Use Big Data Platforms to Process and Analyze Automotive Data • **Practical session** - Case studies showcasing the application of data analytics in the automotive industry	9	5		
	Assignment topics					

Text Book:

1. Adams Niall M, et al. Data Science for Cyber-Security. World Scientific, 25 Sept. 2018.ISBN-13: 9781786345639
2. Chowdhury, Mashrur A., et al. Data Analytics for Intelligent Transportation Systems. Amsterdam, Elsevier, 2017.ISBN-13: 9780443138782
3. Janeja, Vandana P. Data Analytics for Cybersecurity. Cambridge ; New York, Ny, Cambridge University Press, 2022.ISBN-13: 9781108415279
4. McQueen, Bob. Big Data Analytics for Connected Vehicles and Smart Cities. Boston, MA, Artech House, 2017.ISBN-13: 9781630813215
5. McKinney, Wes. Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter.ISBN-13: 9781098104030
6. Root, Alex. Python for Data Analytics. 6 Sept. 2019.ISBN-13: 9781691418831
7. Runkler, Thomas A. Data Analytics. Springer Nature, 13 May 2020. ISBN 9783658297794
8. Verma, Rakesh M, and David J Marchette. Cybersecurity Analytics. CRC Press, 27 Nov. 2019.ISBN-13: 9781032401003

Reference books:

1. "Big Data Analytics for Cyber-Physical Systems: Machine Learning for the Internet of Things" by Tarek Abdel Zaher, Shiguang Wang, and Mohamed Youssef
2. "The Car Hacker's Handbook: A Guide for Penetration Testers" by Craig Smith

3. "Cybersecurity for Connected Cars: Protecting Your Vehicle against Cyber Attacks" by Sujit Ghosh
4. "Electric Vehicle Integration into Modern Power Networks" by Pal B. Ladjevardi and Jinfeng Ren
5. "Data Analytics for Renewable Energy Integration" by Josep M. Guerrero and Babak Badrzadeh