1.1.2 Details of Courses where syllabus revision was carried out

B.E.- Mechanical Engineering

R-22 Curriculum

Course Code	Course Name	% of Change
22MEC14	Machine Design	100%
22MEC15	Metrology and Measurements	20%
22MEC16	Heat and Mass Transfer	2%
22MEC17	Hydraulics and Pneumatics	100%
22MEC19	Mechatronics & IoT	20%
22MEX01	Composite Materials	100%
22MEX02	Tool Design	100%
22MEX03	Non-traditional Machining Processes	100%
22MEX04	Design Concepts in Engineering	100%
22MEX05	Design of Transmission System	100%
22MEX06	Automobile Engineering	100%
22MEX07	Industrial Layout Design and Safety	100%
22MEX08	Modern Robotics	100%
22MEX11	Automotive Materials, Components, Design & Testing	100%
22MEX12	Conventional and Futuristic Vehicle Technology	100%
22MEX13	Renewable Powered Off Highway Vehicles and Emission Control Technology	100%
22MEX14	Vehicle Health Monitoring, Maintenance and Safety	100%
22MEX15	CAE and CFD Approach in Future Mobility	100%
22MEX16	Hybrid and Electric Vehicle Technology	100%
22MEX17	Thermal Management of Batteries and Fuel Cells	100%
22MEX18	Smart Mobility and Intelligent Vehicles	100%

24/06/24

HEAD OF THE DEPARTMENT
DEPARTMENT OF MECHANICAL ENGINEERING,
NANDHA ENGINEERING COLLEGE
ERODE - 638 052.

Course Code	Course Name	% of Change
22MEX21	Turbo Machines	100%
22MEX22	Advanced Internal Combustion Engineering	100%
22MEX23	Gas Dynamics and Jet Propulsion	100%
22MEX24	Refrigeration and Air Conditioning	100%
22MEX25	Thermal Power Engineering	100%
22MEX26	Renewable Energy Technologies	100%
22MEX27	Advanced Vehicle Engineering	100%
22MEX31	Computational Solid Mechanics	100%
22MEX32	Computational Fluid Dynamics and Heat transfer	100%
22MEX33	Theory on Computation and Visualization	100%
22MEX34	Computational Bio- Mechanics	100%
22MEX35	Design of Pressure Vessels	100%
22MEX37	Failure Analysis and NDT Techniques	100%
22MEX38	Machine Learning for Intelligent Systems	100%
22MEX41	Digital Manufacturing and IoT	100%
22MEX42	Additive Manufacturing	100%
22MEX43	Green Manufacturing Design and Practices	100%
22MEX44	Casting and Welding Processes	100%
22MEX45	Environment Sustainability and Impact Assessment	100%
22MEX46	Surface Engineering	100%
22MEX47	Green Supply Chain Management	100%
22MEX48	Product Life Cycle Management	100%
	Average	94%

24.06.24

HEAD OF THE DEPARTMENT
DEPARTMENT OF MECHANICAL ENGINEERING,
NANDHA ENGINEERING COLLEGE
ERODE - 638 052.

NANDHA ENGINEERING COLLEGE

(An Autonomous Institution affiliated to Anna University Chennai and approved by AICTE, New Delhi)
Erode-638 052, Tamilnadu, India, Phone: 04294 – 225585

Curriculum and Syllabi

for

B.E. – Mechanical Engineering [R22]

[CHOICE BASED CREDIT SYSTEM]

(This Curriculum and Syllabi are applicable to Students admitted of 2022-26 and 2023-27 Batches only)

JULY 2024

INSTITUTE VISION AND MISSION	
VISION	• To be an Institute of excellence providing quality Engineering, Technology and Management education to meet the ever changing needs of the society.
MISSION	• To provide quality education to produce ethical and competent professionals with social Responsibility • To excel in the thrust areas of Engineering, Technology and Entrepreneurship by solving real- world problems. • To create a learner centric environment and improve continually to meet the changing global needs.

B.E – MECHANICAL ENGINEERING	
VISION	• To be recognised as a centre of excellence in the field of Mechanical Engineering and to produce competent engineers with multi-disciplinary exposure to meet the changing needs of the society.
MISSION	• To enrich technical knowledge and skills by imparting quality education with ethics and social responsibility. • To empower the students in the thrust areas of Mechanical, Allied Engineering and Entrepreneurship in the continually changing global market. • To provide a conducive learning environment for improving continually to cater the needs of the society.
PROGRAMME EDUCATIONAL OBJECTIVES (PEO)	**The graduates of Mechanical Engineering will be** **PEO1: Core Competency:** A Successful professional with core competency and inter-disciplinary skills to satisfy the Industrial needs. **PEO2: Research, Innovation and Entrepreneurship:** Capable of identifying technological requirements for the society and providing innovative solutions to real time problems. **PEO3: Ethics, Human values and Life-long learning:** able to apply professional and ethical practices in their career through continuous learning.
PROGRAMME SPECIFIC OUTCOMES (PSO)	**The students of Mechanical Engineering will be able to** • Identify, formulate and analyze the problems of Mechanical, Allied Engineering systems and product development. • Apply appropriate computer aided engineering tools for modeling, simulation, analysis, and manufacturing techniques to solve engineering problems.

PROGRAM OUTCOMES:

At the end of this programme the students will be able to

a-l	GRADUATE ATTRIBUTES	PO No.	PROGRAMME OUTCOMES
a	**Engineering Knowledge**	PO1	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
b	**Problem analysis**	PO2	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
c	**Design / development of solutions**	PO3	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.
d	**Conduct investigations of complex problems**	PO4	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.
e	**Modern Tool Usage**	PO5	Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
f	**The Engineer and Society**	PO6	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.
g	**Environment and Sustainability**	PO7	Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge and need for the sustainable development.
h	**Ethics**	PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i	**Individual and Team Work**	PO9	Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
j	**Communication**	PO10	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 and make effective presentations and give and receive clear instructions.
k	**Project Management and Finance**	PO11	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, manage projects and in multidisciplinary environments.
l	**Lifelong Learning**	PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES WITH PROGRAMME OUTCOMES

A broad relation between the Programme Educational Objectives and the outcomes is given in the following table

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES											
	A	B	C	D	E	F	G	H	I	J	K	L
I	3	3	2	3	2	I	I	2	I	2	2	3
2	3	3	3	3	3	I	I	2	I	2	2	3
3	3	3	3	3	3	I	I	2	I	2	2	3

Contribution **I: Reasonable** **2: Significant** **3: Strong**

MAPPING OF PROGRAM SPECIFIC OUTCOMES WITH PROGRAMME OUTCOMES

A broad relation between the Program Specific Objectives and the outcomes is given in the following table

PROGRAM SPECIFIC OUTCOMES	PROGRAMME OUTCOMES											
	A	B	C	D	E	F	G	H	I	J	K	L
I	3	3	2	3	2	I	I	I	I	I	I	2
2	3	3	3	3	3	2	2	3	I	3	3	3

Contribution **I: Reasonable** **2: Significant** **3: Strong**

SEMESTER: I									
S. NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
I	22MAN01	Induction Programme	MC	-	-	-	-	-	-
THEORY									
2	22EYA01	Professional Communication - I	HSMC		4	2	0	2	3
3	22MYB01	Calculus and linear algebra*	BSC		4	3	I	0	4
4	22CYB02	Chemistry for Engineers	BSC		3	3	0	0	3
5	22EEC02	Basic Electrical Engineering	ESC		3	3	0	0	3
6	22MEC02	Engineering Graphics and drafting (Theory + Lab)	ESC		5	3	0	2	4
7	22GYA01	தமிழர் மரபு /Heritage of Tamils	HSMC	-	I	I	0	0	I
PRACTICAL									
8	22GEP01	Engineering Practices Laboratory	ESC		4	0	0	4	2
9	22CYP01	Chemistry Laboratory*	BSC		2	0	0	2	I
Mandatory Non Credit Courses									
10	22MAN02	Soft/Analytical Skills - I	**MC**		3	I	0	2	0
11	22MAN03	Yoga – I*	**MC**		I	0	0	I	0
TOTAL					**30**	**16**	**I**	**13**	**21**

* **Ratified by Eleventh Academic Council**

SEMESTER: II									
S. NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22EYA02	Professional Communication - II	HSMC	22EYA01	4	2	0	2	3
2	22MYB02	Partial Differential Equations and Transform Techniques*	BSC		4	3	1	0	4
3	22PYB04	Physics for Mechanical Engineering	BSC		3	3	0	0	3
4	22CSC01	Problem Solving and C Programming*	ESC		3	3	0	0	3
5	22ECC03	Basic Electronics and instrumentation Engineering	ESC		3	3	0	0	3
6	22MEC03	Engineering Mechanics	ESC		3	2	1	0	3
7	22GYA02	தமிழரும் தொழில்நுட்பமும் /Tamils and Technology	HSMC	22GYA01	1	1	0	0	1
PRACTICAL									
8	22CSP01	Problem Solving and C Programming Laboratory*	ESC		4	0	0	4	2
9	22PYP01	Physics Laboratory*	BSC		2	0	0	2	1
Mandatory Non Credit Courses									
10	22MAN04	Soft / Analytical Skills - II	MC	22MAN02	3	1	0	2	0
11	22MAN05	Yoga – II*	MC		1	0	0	1	0
TOTAL					**31**	**18**	**2**	**11**	**23**

* **Ratified by Eleventh Board of studies**

SEMESTER: III									
S. NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22MYB03	Statistics And Numerical Methods	BSC		4	3	1	0	4
2	22MEC04	Engineering Thermodynamics	PCC		3	2	1	0	3
3	22MEC05	Fluid Mechanics and Machinery (Theory + Lab)	ESC		5	3	0	2	4
4	22MEC06	Manufacturing Processes	PCC		3	3	0	0	3
5	22MEC07	Engineering materials and metallurgy	PCC		3	3	0	0	3
PRACTICAL									
6	22MEP02	Computer Aided Machine Drawing	BSC		4	0	0	4	2
Mandatory Non Credit Courses									
7	22MAN07# / 22MAN07R##	Soft / Analytical Skills - III	MC	-	3	1	0	2	0
8	22MAN09	Indian Constitution	MC		1	1	0	0	0
TOTAL					**26**	**16**	**2**	**8**	**19**

Applicable for 2022-26 Batch only
Applicable for 2023-27 Batch only

SEMESTER: IV									
S. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22MEC09	Thermal Engineering Systems	PCC	22MEC04	4	3	1	0	4
2	22MEC10	Subtractive Manufacturing Processes	PCC	2MEC06	3	3	0	0	3
3	22MEC11	Strength of Materials (Theory + Lab)	PCC		5	3	0	2	4
4	22MEC12	Theory of Machines (Theory + Lab)	PCC		4	3	0	2	4
5	E1	Elective(OEC/PEC)	OEC / PEC		3	3	0	0	3
PRACTICAL									
6	22MEP03	Thermal Engineering Systems Laboratory	PCC		4	0	0	4	2
7	22MEP04	Subtractive Manufacturing Processes Laboratory	PCC		4	0	0	4	2
Mandatory Non Credit Courses									
8	22MAN08[#]/ 22MAN08R[##]	Soft/Analytical Skills - IV	MC	-	3	1	0	2	0
9	22MAN06	Environmental Science	MC		2	0	0	2	0
10	22GED01	Personality and Character Development	MC		2	0	0	2	0
TOTAL					**34**	**16**	**1**	**18**	**22**

* **Ratified by Twelfth Academic Council**
[#] **Applicable for 2022-26 Batch only**
[##] **Applicable for 2023-27 Batch only**

SEMESTER: V									
S. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22MEC14	Machine Design	PCC		**4**	**3**	**1**	**0**	**4**
2	22MEC15	Metrology and Measurements	PCC		**3**	**3**	**0**	**0**	**3**
3	22MEC16	Heat and Mass Transfer	PCC		**3**	**3**	**0**	**0**	**3**
4	22MEC17	Hydraulics and Pneumatics	PCC		**3**	**3**	**0**	**0**	**3**
5	E2	Elective(PEC)	PEC		**3**	**3**	**0**	**0**	**3**
6	E3	Elective(OEC/PEC)	PEC		**3**	**3**	**0**	**0**	**3**
PRACTICAL									
7	22MEP05	Heat and Mass Transfer Laboratory	PCC		4	0	0	4	2
8	22MEP06	Metrology and Measurements Laboratory	PCC		4	0	0	4	2
Mandatory Non Credit Courses									
9	22MAN10R	Communication and Quantitative Reasoning	MC	-	3	1	0	2	0
TOTAL					**30**	**19**	**1**	**10**	**23**

SEMESTER: VI									
S. NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22MEC18	Finite Element Analysis	PCC		3	3	0	0	3
2	22MEC19	Mechatronics & IoT	PCC		3	3	0	0	3
3	EM1	Elective - Management	HSMC		3	3	0	0	3
4	E4	Elective(PEC)	PEC		3	3	0	0	3
5	E5	Elective(PEC)	PEC		3	3	0	0	3
6	E6	Elective(OEC)	OEC		3	3	0	0	3
PRACTICAL									
7	22MEP07	Computer Aided Analysis Laboratory	PCC		4	0	0	4	2
8	22MEP08	Mechatronics & IoT Laboratory	PCC		4	0	0	4	2
TOTAL					**26**	**18**	**0**	**08**	**22**

VERTICAL 1 DESIGN ENGINEERING										
S. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**	**P.S**
1.	22MEX01	Composite Materials	PEC	-	3	3	0	0	3	V - VII
2.	22MEX02	Tool Design	PEC	-	3	3	0	0	3	V - VII
3.	22MEX03	Non-traditional Machining Processes	PEC	-	3	3	0	0	3	V - VII
4.	22MEX04	Design Concepts in Engineering	PEC	-	3	3	0	0	3	V - VII
5.	22MEX05	Design of Transmission System	PEC	**22MEC14**	3	3	0	0	3	V - VII
6.	22MEX06	Automobile Engineering	PEC	-	3	3	0	0	3	V - VII
7.	22MEX07	Industrial Layout Design and Safety	PEC	-	3	3	0	0	3	V - VII
8.	22MEX08	Modern Robotics	PEC	-	3	3	0	0	3	V - VII
VERTICAL 2 MODERN MOBILITY SYSTEMS										
S. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**	**P.S**
1.	22MEX11	Automotive Materials, Components, Design & Testing	PEC	-	3	3	0	0	3	V - VII
2.	22MEX12	Conventional and Futuristic Vehicle Technology	PEC	-	3	3	0	0	3	V - VII
3.	22MEX13	Renewable Powered Off Highway Vehicles and Emission Control Technology	PEC	-	3	3	0	0	3	V - VII
4.	22MEX14	Vehicle Health Monitoring, Maintenance and Safety	PEC	-	3	3	0	0	3	V - VII
5.	22MEX15	CAE and CFD Approach in Future Mobility	PEC	-	3	3	0	0	3	V - VII
6.	22MEX16	Hybrid and Electric Vehicle Technology	PEC	-	3	3	0	0	3	V - VII
7.	22MEX17	Thermal Management of Batteries and Fuel Cells	PEC	-	3	3	0	0	3	V - VII
8.	22MEX18	Smart Mobility and Intelligent Vehicles	PEC	-	3	3	0	0	3	V – VII

VERTICAL 3 THERMAL ENGINEERING										
S. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**	**P.S**
1.	22MEX21	Turbo Machines	PEC	-	3	3	0	0	3	V - VII
2.	22MEX22	Advanced Internal Combustion Engineering	PEC	-	3	3	0	0	3	V - VII
3.	22MEX23	Gas Dynamics and Jet Propulsion	PEC	-	3	3	0	0	3	V - VII
4.	22MEX24	Refrigeration and Air Conditioning	PEC	-	3	3	0	0	3	V - VII
5.	22MEX25	Thermal Power Engineering	PEC	-	3	3	0	0	3	V - VII
6.	22MEX26	Renewable Energy Technologies	PEC	-	3	3	0	0	3	V - VII
7.	22MEX27	Advanced Vehicle Engineering	PEC	-	3	3	0	0	3	V - VII
8.	22MEX28	Power Plant Engineering	PEC	-	3	3	0	0	3	V - VII
VERTICAL 4 COMPUTATIONAL ENGINEERING										
S. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**	**P.S**
1.	22MEX31	Computational Solid Mechanics	PEC	-	3	3	0	0	3	V - VII
2.	22MEX32	Computational Fluid Dynamics and Heat transfer	PEC	-	3	3	0	0	3	V - VII
3.	22MEX33	Theory on Computation and Visualization	PEC	-	3	3	0	0	3	V - VII
4.	22MEX34	Computational Bio-Mechanics	PEC	-	3	3	0	0	3	V - VII
5.	22MEX35	Design of Pressure Vessels	PEC	-	3	3	0	0	3	V - VII
6.	22MEX36	CAD and CAE	PEC	-	3	3	0	0	3	V - VII
7.	22MEX37	Failure Analysis and NDT Techniques	PEC	-	3	3	0	0	3	V - VII
8.	22MEX38	Machine Learning for Intelligent Systems	PEC	-	3	3	0	0	3	V - VII

VERTICAL 5 DIGITAL AND GREEN MANUFACTURING										
S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PRE REQUISITE	CONTACT PERIODS	L	T	P	C	P.S
1.	22MEX41	Digital Manufacturing and IoT	PEC	-	3	3	0	0	3	V - VII
2.	22MEX42	Additive Manufacturing	PEC	-	3	3	0	0	3	V - VII
3.	22MEX43	Green Manufacturing Design and Practices	PEC	-	3	3	0	0	3	V - VII
4.	22MEX44	Casting and Welding Processes	PEC	-	3	3	0	0	3	V - VII
5.	22MEX45	Environment Sustainability and Impact Assessment	PEC	-	3	3	0	0	3	V - VII
6.	22MEX46	Surface Engineering	PEC	-	3	3	0	0	3	V - VII
7.	22MEX47	Green Supply Chain Management	PEC	-	3	3	0	0	3	V - VII
8.	22MEX48	Product Life Cycle Management	PEC	-	3	3	0	0	3	V - VII
(E) MINOR DEGREE										
MINOR I ELECTRIC VEHICLE TECHNOLOGIES										
S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PRE REQUISITE	CONTACT PERIODS	L	T	P	C	P.S
1.	22MEM01	Basics of Electric Vehicles	OEC	-	3	3	0	0	3	V - VII
2.	22MEM02	Electric Vehicle Architecture and Control System	OEC	-	3	3	0	0	3	V - VII
3.	22MEM03	Materials for Electric Vehicles	OEC	-	3	3	0	0	3	V - VII
4.	22MEM04	Powertrain Design for Electric Vehicles	OEC	-	3	3	0	0	3	V - VII
5.	22MEM05	Battery Management	OEC	-	3	3	0	0	3	V - VII
6.	22MEM06	AI and IoT for Electric Vehicles	OEC	-	3	3	0	0	3	V - VII
7.	22MEM07	Autonomous Vehicles	OEC	-	3	3	0	0	3	V - VII
8.	22MEM08	Fuel Cell Technology & Safety Regulations	OEC	-	3	3	0	0	3	V - VII
(F) MANAGEMENT ELECTIVES										
1.	22GEA02	Principles of Management	HSMC	-	3	3	0	0	3	VI
1.	22GEA03	Total Quality Management	HSMC	-	3	3	0	0	3	VI
2.	22GEA04	Professional Ethics	HSMC	-	3	3	0	0	3	Vi

22MEC14 MACHINE DESIGN

	L	T	P	C
	3	1	0	4

PREREQUISITE :

Course Objective:	• To introduce the design methodology of machine elements • To acquire knowledge on analysis of forces acting on the machine elements and appropriate design methodology • To analyse the stresses acting on the temporary and permanent joints • To gain knowledge about the design of couplings and/or springs • To teach various standards, and selection procedures of machine elements

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply concepts of strength of materials to estimate the stresses in a machine element and predict failure of components.	Ap	20%
CO2	Analyse the effect of fatigue load on machine elements and factors affecting it to predict failure.	An	20%
CO3	Design the machine elements such as Shafts, Keys, springs and bearings	An/E	40%
CO4	Design the various joints such as temporary joints, permanent joints and couplings	E	20%
CO5	Implement standards, codes, and regulations in machine design	U/Ap	Internal Assessment

UNIT I : STRESSES IN MACHINE ELEMENTS	**(9+3)**
Procedure in design process - factors influencing machine design - selection of materials based on mechanical properties preferred numbers, fits and tolerance - direct, bending and torsional stress equation - Modes of failure- bending stress incurved beams - crane hook and 'C' frame - factor of safety - theories of failures	
UNIT II :VARIABLE STRESSES AND DESIGN OF SHAFTS	**(9+3)**
Variable stresses in machine parts - stress concentration factor - cyclic stresses - fatigue and endurance limit - Goodman and Soderberg methods - combined normal stress and variable stress - design of solid and hollow shafts based on strength and rigidity	
UNIT III : PERMANENT AND TEMPORARY JOINTS	**(9+3)**
Welded joints - types - basic weld symbols - strength of transverse and parallel fillet welded joints - eccentrically loaded welded joints. Threaded joints - terms - forms - design of bolted joints under eccentric loading - introduction to riveted joints	
UNIT IV : DESIGN OF COUPLINGS AND SPRINGS	**(9+3)**
Couplings - types - design of muff coupling, unprotected type flange coupling, bushed pin flexible coupling - Introduction to ELBO flexible pin-type coupling, springs- types, helical springs, materials, end connections, terms used in compression springs - stresses and deflection in helical springs of circular wire - surge in springs - design of leaf springs - stress and deflection equation, nipping	

UNIT V : BEARINGS	(9+3)

Sliding contact bearings – theory of lubrication, hydrodynamic bearings, Sommerfield number – design of hydrodynamic bearings – rolling contact bearings, static and dynamic load capacity, cubic mean load, variable load, probability of survival, selection of deep groove ball bearing, Introduction to Magnetic bearings and its applications.

S. No.	Practice Titles	Unit
1	Fits and Tolerances	1
2	Welded joints	3
3	Helical Springs	4

TOTAL : 60 Hours (45 L +15 T)

TEXT BOOKS

1. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 10th ed., McGraw-Hill Education, 2015
2. Bhandari V.B, "Design of Machine Elements", 4th ed., McGraw Hill Education India Private Limited, 2017

REFERENCES:

1. Khurmi. R.S and Gupta. J. K, "A Textbook of Machine Design", S. Chand and Company Ltd., New Delhi, 2014
2. Jalaludeen S.Md, "Machine Design (Volume-1)", 4th ed., Anuradha Publications, Chennai, 2011
3. Sundararajamoorthy T. V. Shanmugam. N, "Machine Design", Anuradha Publications, Chennai, 2003
4. Robert C. Juvinall, Kurt M. Marshek, "Machine Component Design", Wiley India Pvt Ltd., 2016
5. Ganesh Babu.K, Srithar.K, "Design of Machine Elements", 2nd ed., McGraw Hill Education (India) Private Limited, 2009

Mapping of COs with POs / PSOs

Cos	Pos												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2		3											3	
3			3										3	
4				2									3	
5								2						
CO (W.A)	3	3	3	2				2					3	

22MEC15 METROLOGY AND MEASUREMENTS				
	L	T	P	C
	3	0	0	3
PREREQUISITE :				

Course Objective:	• To introduce the principles of metrology and measurements • To acquire knowledge on measurement parameters and its applications • To acquire knowledge on the concept of various measurements like linear and angular measurements • To impart knowledge on statistical measurements and surface finish • To gain knowledge on laser and advances in metrology system

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the concept of measurement system for industrial components	Ap	30
CO2	Apply the various measuring methods in mechanical applications	Ap	30
CO3	Design the various components using measuring instruments	Ap	20
CO4	Develop competence in form measurement and optical measurement methods, including 3D surface metrology	An	20
CO5	Engage in independent study as a member of a team or individual and make effective oral presentation on measurement systems	U	Internal Evaluation

UNIT I : MEASUREMENT SYSTEMS	**(9)**
General concept - units and standards - characteristics of measuring instruments - sensitivity, stability, range, accuracy and precision - static and dynamic response - repeatability, hysteresis - systematic and random errors - correction, calibration - interchangeability	
UNIT II : PARAMETER MEASUREMENTS	**(9)**
Measurement of force, torque, power using mechanical, pneumatic, hydraulic, electrical instruments - flow measurement - rotameter, pitot tube - Temperature measurement - bimetallic strip, thermocouple, electrical resistance thermometer	
UNIT III : LINEAR AND ANGULAR MEASUREMENTS	**(9)**
Linear measuring instruments - vernier, micrometer, slip gauges, limit gauges, tool maker's microscope - interferometry, optical flats, comparators - mechanical, pneumatic, electrical applications - angular measurements - sine bar, sine center, bevel protractor, autocollimator, Angle Dekkor.	
UNIT IV : FORM MEASUREMENT	**(9)**
Fundamentals of GD & T - Measurement of Screw Thread - Measurement of Gears - Measurement of straightness, flatness and roundness - measurement of surface finish - stylus based - Tomlinson surface meter and Taylor-Hobson Talysurf - optical measurement - light cross section method - Introduction to 3D surface metrology	
UNIT V : ADVANCED METROLOGY	**(9)**
Precision instruments based on laser principles - interferometer - application in linear, angular measurements - Coordinate Measuring Machine (CMM) - constructional features - types, applications - computer aided inspection - Introduction to machine vision system - Demonstration of Modern Measurement System for Industrial Applications.	

TEXT BOOKS:

1. Thomas G. Beckwith, Roy D, Marangoni, John H.Lienhard V., "Mechanical Measurements", 6th ed., Pearson Education India, 2014
2. Jain R.K., "Engineering Metrology", 20th ed, Khanna Publishers, 2009

REFERENCES:

1. Raghavendra N.V, Krishnamurthy L, "Engineering Metrology and Measurements", 1st ed., Oxford University Press, 2013
2. R.K.Rajput A textbook of measurement and metrology ,S.K. Kataria & Sons,2013.
3. Gupta.I.C., "Engineering Metrology", 10th ed., Dhanpat Rai Publications, 2013
4. Anand K Bewoor, Vinay A Kulkarni, "Metrology & Measurement", McGraw Hill Education, 2009
5. Mahajan.M, "Engineering Metrology", Dhanapat Rai publications, 2014
6. Tayal A.K, "Instrumentation and Mechanical Measurements", 4th ed., Galgotia Publications, 2000

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	2
2		2											2	
3			2										1	
4					2									1
5					2									2
CO (W.A)	3	2	2		2								1.67	1.67

22MEC16 HEAT AND MASS TRANSFER

L	T	P	C
3	0	0	3

PREREQUISITE :

Course Objective:

- To introduce the concept of heat conduction in various systems.
- To analyze about the internal heat generation and transient heat conduction.
- To acquire knowledge on convection in various systems.
- To acquire knowledge on Boiling and Condensation, radiation heat transfer.
- To learn the basic of heat exchangers, develop the basic concept, diffusion and convective mass transfer.

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the concept of heat transfer to calculate the rate of heat transferred through conduction and convection in various thermal systems.	Ap	40%
CO2	Numerically determine and compare the emissivity of grey bodies with that of a black body.	Ap	20%
CO3	Compare the modes of heat transfer by solving numerical problems relevant to real-time applications.	Ap	20%
CO4	Analyze the transfer of matter on a microscopic level as a result of diffusion from a region of higher concentration to lower concentration region.	An	20%
CO5	Engage in an independent study to deliver a compelling oral presentation on heat transfer modes in diverse thermal applications.	U	Internal Assessment

UNIT I : STEADY STATE HEAT CONDUCTION	**(9)**
Mechanisms of heat transfer - General heat conduction equation in Cartesian coordinates –One dimensional steady state heat conduction in composite and plane walls with constant thermal conductivity - critical radius of insulation - Rectangular plate fins and pin fins with uniform cross section - Efficiency and effectiveness - circumferential fins.	
UNIT II - CONDUCTION WITH HEAT GENERATION	**(9)**
Solid cylinder with internal heat generation - Transient heat conduction - plane wall with negligible internal resistance - heat flow in an infinitely thick plate - chart solutions of transient heat conduction problems in plane wall.	
UNIT III - CONVECTION	**(9)**
Thermal and velocity boundary layer in flow over flat plate and flow through circular pipe - forced convection - correlations for flow over flat plate - flow across tube banks - correlations for flow through circular tubes - Natural convection in vertical and horizontal plates	
UNIT IV - RADIATION, BOILING AND CONDENSATION	**(9)**
Thermal radiation - emissive power - absorption, reflection and transmission - Plank's, Wien's displacement, Stefan- Boltzmann, Kirchhoff's laws - emissivity - grey body - Radiation shields - pool boiling curve for water - boiling correlations -Nusselt's theory - condensation on vertical surfaces and horizontal tubes	
UNIT V – HEAT EXCHANGERS AND MASS TRANSFER	**(9)**
Types of heat exchangers - overall heat transfer coefficient - fouling factors - LMTD and NTU methods - Diffusion mass transfer - Fick's law of diffusion - diffusion coefficient - equimolar counter diffusion - concentration boundary layer - governing equations - convective mass transfer correlations	
TOTAL = 45 PERIODS	

TEXT BOOKS

1. Sachdeva.R.C, "Fundamentals of Engineering Heat and Mass transfer", 6th ed., New age international publishers, 2022.
2. Yunus A Cengel, "Heat and Mass Transfer", 6th ed., McGraw Hill Education (India) Pvt Ltd, 2020

REFERENCES:

1. Kothandaraman.C.P, "Fundamentals of Heat and Mass transfer", 4th ed., New age international publishers, 2012
2. Nag.P.K, "Heat and Mass Transfer", 3rd ed., McGraw Hill Education, 2011
3. Holman.J.P, "Heat Transfer", McGraw Hill Education (India) Pvt Ltd, 2017
4. Incropera and Dewitt, "Fundamentals of Heat and Mass Transfer", 7th ed., Wiley India Pvt Ltd, 2013

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	
2	3												2	
3	3												2	
4		3											2	
5										2				
CO (W.A)	**3**	**3**								**2**			**2**	

22MEC17 HYDRAULICS AND PNEUMATICS				
	L	T	P	C
	3	0	0	3
PREREQUISITE :				

Course Objective:	• To provide the knowledge on the working principles of fluid power systems. • To study the fluids and components used in modern industrial fluid power system. • To develop the design, construction and operation of fluid power circuits. • To learn the working principles of pneumatic power system and its components. • To provide the knowledge of trouble shooting methods in fluid power systems.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the concepts of fluid power in controlling actuators/components.	AP	20
CO2	Apply the concepts of hydraulics and pneumatics to obtain automation industrial applications.	AP	40
CO3	Analyze various fluid power circuits and select suitable actuators and control components.	AN	20
CO4	Design hydraulic and pneumatic circuits to meet the given specifications.	AN / C	20
CO5	Formulate, Design, Implement, Demonstrate, Analyze a mini project relate to the course.	AN / C	Internal Assessment

UNIT I - FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS	**(9)**
Fluid power systems – Introduction to Fluid power – Advantages and Applications –Types of fluids - Properties of fluids – Basics of Hydraulics – Pascal's Law – Problems, Sources of Hydraulic power: Pumping Theory – Pump Classification – Construction, Operation, Advantages, Disadvantages and Applications	
UNIT II - HYDRAULIC ACTUATORS AND CONTROL COMPONENTS	**(9)**
Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary Actuators – Hydraulic motors - Control Components: Direction Control, Flow control and pressure control valves – Types, Construction, Operation and Applications – Fluid Power ANSI Symbols	
UNIT III - HYDRAULIC CIRCUITS AND SYSTEMS	**(9)**
Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double-Pump, Pressure Intensifier, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Deceleration circuits – Applications – Mechanical, hydraulic servo systems	
UNIT IV - PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS	**(9)**
Properties of air – Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Compressors and types, Pneumatic actuators, Design of Pneumatic circuit – classification – single cylinder and multi cylinder circuits – Cascade method – Electro Pneumatic System – Elements – timer circuits	
UNIT V – TROUBLE SHOOTING AND APPLICATIONS	**(9)**
Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Surface grinding, Press and Forklift applications – Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits – IoT in Hydraulics and pneumatics	
TOTAL = 45 PERIODS	

TEXT BOOKS:

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. James A. Sullivan, "Fluid Power Theory and Applications", Fourth Edition, Prentice Hall, 1997

REFERENCES:

1. Jagadeesha. T., "Pneumatics Concepts, Design and Applications ", Universities Press, 2015.
2. Joshi.P., Pneumatic Control", Wiley India, 2008.
3. Majumdar, S.R., "Oil Hydraulics Systems – Principles and Maintenance",TataMcGraw Hill, 2001.
4. Shanmugasundaram.K., "Hydraulic and Pneumatic Controls". Chand & Co, 2006.
5. Srinivasan.R., "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 3rd edition,2019.

CO	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2	3												3	
3		3											3	
4			3										3	
5			2						2	1	1	1	3	2
CO (W.A)	**3**	**3**	**2.5**						**2**	**1**	**1**	**1**	**3**	**2**

22MEC19 MECHATRONICS & IoT

L	T	P	C
3	0	0	3

PRE REQUISITE : 22MEC17

Course Objectives:	• To make students get acquainted with the sensors and the actuators in mechatronics systems • To provide insight into the control systems in Mechatronics • To understand the concepts and programming in PLC • To make students familiarize with the fundamentals of IoT systems • To inculcate skills in the design and development of mechatronics and IoT based systems

	Course Outcomes The Student will be able to	Cognitive level	Weightage of COs in End Semester Examination
CO1	Apply the concept of sensors and actuator for mechatronics application	Ap	40%
CO2	Analyze the output response of various control modes of systems	An	20%
CO3	Investigate and analyze the operations of microcontroller and PLC for mechatronics applications	An	20%
CO4	Interfacing the IoT concepts in the Mechatronics systems	Ap	20%
CO5	Engage in an independent study as a member of a team or individual and investigate, design, develop a mini-project demonstrating the Mechatronics and IoT applications	C	Internal Assessment

UNIT I - SENSORS AND ACTUATORS	**(9)**
Introduction to Mechatronics - emerging areas of Mechatronics - sensors and transducers - static and dynamic characteristics, transducers - resistive, capacitive, inductive and resonant, optical sensors - photodetectors - vision systems - laser - fibre optic - non-fibre optic, solid state sensors, piezoelectric and ultrasonic sensors - humidity sensor - temperature sensors - actuators - brushless permanent magnet DC motor - PM, VR and hybrid stepper motors - DC and AC servo motors	
UNIT II - CONTROL SYSTEMS, MICROPROCESSOR AND MICROCONTROLLER	**(9)**
Control systems - open and closed loop systems - automatic control of water level - analogue and digital control systems - control modes - two step, proportional, derivative, integral and PID controllers - microprocessor - architecture of 8085 microprocessor - pin configuration - architecture of 8051 microcontroller - single-chip microcontroller systems - single-board microcontroller systems - single-board computer systems - embedded systems - peripherals - typical architecture of a CAN based system	
UNIT III - PROGRAMMABLE LOGIC CONTROLLER	**(9)**
Programmable logic controller - architecture - input / output processing - ladder diagrams - latching, sequencing, timers, counters and internal relays - data handling - selection of PLC - application of PLCs for control	
UNIT IV - FUNDAMENTALS OF IoT AND CONTROLLERS	**(9)**
TThe Internet of Things (IoT) - introduction to the IoT framework - IoT enabling technologies - the effective implementation of IoT - foundation topics: Programming Languages: C and Python - Arduino: the Arduino Boards - Arduino peripherals- Arduino IDE - ESP series Wi-Fi module - (typical peripherals) interfacing and controlling I/O devices by Arduino : LEDs - sensor and actuator interactions	
UNIT V – MECHATRONICS AND IoT CASE STUDIES	**(9)**
Mechatronics systems: Drone actuation and Control -Autonomous Robot with Vision System, Automotive Mechatronics: Electronic Ignition System - ABS - EBD - Adaptive Cruise Control. IoT case studies: Remote Monitoring Systems- Remotely Operated Autonomous Systems - Centralized Water Management System - IoT sensors for climate control - IoT Enabled Robotic Camera Dolly - Portable, Wireless, Interactive IoT Sensors for Agriculture - IoT Vehicle Management System with Network Selection	

TEXT BOOKS:

1. D.A. Bradley, N.C. Burd, D. Dawson, A.J. Loader, "Mechatronics: Electronics in Products and Processes", Routledge, 2018.
2. S.H. Sami and G. Kisheen Rao, "The Internet of Mechanical Things: The IoT Framework for Mechanical Engineers", CRC Press, 2022.

REFERENCES:

1. John Billingsley, "Essentials of Mechatronics", Wiley, 2006.
2. David H., Gonzalo S., Patrick G.,Rob B. and Jerome H.,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", Pearson Education, 2018
3. Nitin G and Sharad S, "Internet of Things: Robotic and Drone Technology", CRC Press, 2022
4. Newton C. Braga, "Mechatronics for The Evil Genius", McGrawHill, 2005.
5. Bell C., "Beginning Sensor Networks with Arduino and Raspberry Pi", Apress, 2013

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3												3	1
2		3											3	1
3		3		1									3	1
4	3												3	1
5			1	2	1				1	1	2	1	3	1
CO (W. A)	**3**	**3**	**1**	**1.5**	**1**				**1**	**1**	**2**	**1**	**3**	**1**

22MEX01 COMPOSITE MATERIALS

	L	T	P	C
	3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To introduce the fundamentals and manufacturing aspects of composite materials • To acquire knowledge on Lamina Constitutive Equations and analysis of laminated flat plates • To introduce the thermal analysis of various laminates • To understand various failure criterions related to laminated plates • To gain knowledge about thermal analysis of composites

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the rule of mixtures to predict the properties of composite materials.	Ap	20%
CO2	Analyze the mechanical properties and applications of various composites.	An	20%
CO3	Develop the role of interfaces in composite manufacturing.	Ap	20%
CO4	Make use of strength analysis techniques to predict the failure of laminated plates	Ap	20%
CO5	Evaluate the Coefficient of Thermal Expansion of composites by selecting a thermal analysis	An	20%

UNIT I- INTRODUCTION TO COMPOSITE MATERIALS	**(9)**
Definition - matrix materials - polymers - metals - ceramics - reinforcements - particles, whiskers, inorganic fibers, metal filaments - ceramic fibers - fiber fabrication - natural composite wood, jute - advantages and drawbacks of composites over monolithic materials - mechanical properties and applications of composites, particulate reinforced composite materials, dispersion strengthened composite, fiber reinforced composites - rule of mixtures - characteristics of fiber reinforced composites, manufacturing fiber and composite .	
UNIT II - MANUFACTURING OF COMPOSITES	**(9)**
Manufacturing of Polymer Matrix Composites (PMCs) - handlay up, spray technique, filament winding, pultrusion, Resin Transfer Moulding (RTM) - bag moulding, injection moulding, Sandwich Mould Composites (SMC) - manufacturing of Metal Matrix Composites (MMCs) - solid state, liquid state, vapour state processing, manufacturing of Ceramic Matrix Composites (CMCs) - hot pressing - reaction bonding process - infiltration technique, direct oxidation – interfaces.	
UNIT III - INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS	**(9)**
Lamina Constitutive Equations: Lamina Assumptions - macroscopic viewpoint - generalized Hooke's Law - reduction to Homogeneous Orthotropic Lamina - Isotropic limit case, Orthotropic Stiffness matrix (Qij), definition of stress and moment resultants - strain displacement relations - basic assumptions of laminated anisotropic plates - laminate constitutive equations - coupling - Interactions, balanced laminates, symmetric laminates, angle ply laminates, cross ply laminates - laminate structural moduli - evaluation of lamina properties from laminate tests - quasi Isotropic laminates - determination of lamina stresses within Laminates.	

UNIT IV - LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES	(9)
Introduction - maximum stress and strain criteria - Von-Misses yield criterion for isotropic materials - generalized Hill'scriterion for anisotropic materials - Tsai-Hill's failure criterion for composites - tensor polynomial (Tsai-Wu) - failure criterion - prediction of laminate failure equilibrium equations of motion - energy formulations - static bending analysis -buckling analysis - free vibrations - natural frequencies .	
UNIT V – THERMAL ANALYSIS	**(9)**
Assumption of constant Coefficient of Thermal Expansion (C.T.E.) - modification of Hooke's law - modification of laminate constitutive equations - orthotropic lamina C.T.E's - C.T.E's for special laminate configurations - unidirectional, off-axis,symmetric balanced laminates, zero C.T.E laminates, thermally quasi-isotropic laminates	
TOTAL = 45 PERIODS	

TEXT BOOKS

1.Malik, P.K., "Fiber Reinforced Composite: Materials, Manufacturing and Design", 3rd ed., CRC Press, 2007

2. Ronald F. Gibson, "Principles of Composite Material Mechanics ", 2nd ed., CRC Press, 2007

REFERENCES:

1.Michael Hyer and Scott R White, " Stress Analysis of Fibre Reinforced Composite Materials", International edition, McGraw-Hill Education, 1998

2.Issac M. Daniel and Oril Shai, "Engineering Mechanics of Composite Materials", 2nd ed., Oxford UniversityPress, 2005

3.Bhagwan D. Agarwal, Lawrence J. Broutman and K. Chandrashekhara, "Analysis and Performance of Fiber Composites", 3rd ed., Wiley Publications, 2012

4.Mallick.P.K and Newman.S, "Composite Materials Technology: Processes and Properties", Hanser Gardner Publications,1991

5.Deborah D. L. Chung, " Composite Materials: Science and Applications", 2nd ed., Springer, 2012

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2												2	
2		2											2	
3			2										2	
4				1									2	
5					1		1	2	1	1		2	2	
CO (W.A)	2	2	2	1	1	2	1	2	1	1		2	2	

22MEX02 TOOL DESIGN

	L	T	P	C
	3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To teach students the fundamentals of work holding devices. • To enable the students design tools, dies, jigs and fixtures. • To teach students to analyze and optimize an existing jigs. • To gain knowledge about the design of various fixtures. • To expose students to design of dies for press work and forging

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply general considerations in the design of jigs and fixtures and their methods of construction.	Ap	20%
CO2	Apply principles of mechanical, pneumatic, and hydraulic clamping.	Ap	20%
CO3	Comprehend the metal cutting process and selection of appropriate tool materials	Ap	20%
CO4	Analyze the required specifications of a press for required operations	An	20%
CO5	Identify the importance of forging die design, including flow lines, parting lines, and materials for die blocks.	An	20%

UNIT I- DESIGN OF CUTTING TOOLS	**(9)**
Metal cutting process - selection of tool materials - design of single point and multipoint cutting tool - form tools, drills, milling cutters, broaches and chip breakers - problems on design of single point cutting tools only .	
UNIT II - LOCATING AND CLAMPING METHODS	**(9)**
Basic principles of location - locating methods and devices - principles of clamping - mechanical, pneumatic and hydraulic actuation - clamping force analysis - design problems.	
UNIT III - DESIGN OF JIGS	**(9)**
Types of drill jigs - general considerations in the design of drill jigs - drill bushings - types, methods of construction- simple designs of plate, channel, boxes, post, angle plate, turnovers and pot jigs.	
UNIT IV - DESIGN OF FIXTURES	**(9)**
Design principles - types of fixtures - fixtures for machine tools: lathe, milling, boring, broaching and grinding - assembly fixtures - inspection and welding fixtures.	
UNIT V – DESIGN OF DIES	**(9)**
Press tools - Fundamentals of die-cutting operations - Cutting action in punch and die operations - Die clearance - Blanking and Piercing Die construction - Pilots - Strippers and Pressure Pads - Press work materials - Strip layout - Design of simple progressive and compound die sets - Forging Die - Flow lines, parting lines, open and close die forging; Materials for die block.	
TOTAL = 45 PERIODS	

TEXT BOOKS

1. Donaldson, Lecain and Goold, "Tool Design", 3rd ed., Tata McGraw Hill, 2012
2. John G. Nee, "Tool Design", 6th ed., Society of Manufacturing Engineers, 2010

REFERENCES:

1. Venkataraman. K, "Design of Jigs Fixtures and Press Tools", Tata McGraw Hill, New Delhi, 2005
2. Joshi. P.H, "Jigs and Fixtures", 2nd ed., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2004
3. Elanchezhian. C, "Design of Jigs Fixtures and Press Tools", EswarPress,Chennai, 2004
4. Hoffman, "Jigs and Fixture Design", Thomson Delmar Learning, Singapore, 2004
5. VukotaBoljanovicPaquin .J. R, "Die Design Fundamentals", 3rd ed., Industrial Press, 2005

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2			2									2	
2		2											2	
3			2										2	
4													2	
5				2	2	1	2	1	1	1		2	2	
CO (W.A)	2	2	2	2	2	1	2	1	1	1		2	2	

22MEX03 NON TRADITIONAL MACHINING PROCESSES

L	T	P	C
3	0	0	3

PREREQUISITE :

Course Objective:

- To classify non-traditional machining processes and describe mechanical energy based non-traditional machining processes.
- To differentiate chemical and electro chemical energy-based processes.
- To describe thermo-electric energy-based processes
- To explain nano finishing processes.
- To introduce hybrid non-traditional machining processes and differentiate hybrid non-traditional machining processes.

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Formulate different types of non-traditional machining processes and evaluate mechanical energy based non-traditional machining processes.	AP	30
CO2	Investigate the mechanisms and characteristics of mechanical energy-based processes, such as Ultrasonic Machining and Water Jet Machining.	AN	30
CO3	Compare the advantages and limitations of USM and WJM against other non-traditional methods, such as EDM or Laser Machining, with respect to specific manufacturing scenarios.	E	20
CO4	Develop criteria for selecting nano finishing processes by integrating knowledge of material properties, desired surface finish, and production volume.	AN	20
CO5	Analyse hybrid non-traditional machining processes and differentiate non- traditional machining processes.	AN	Internal Assessment

UNIT I - INTRODUCTION AND MECHANICAL ENERGY BASED PROCESSES	**(9)**
Introduction - Need for non-traditional machining processes - Classification of non-traditional machining processes - Applications, advantages and limitations of non-traditional machining processes - Abrasive jet machining, Abrasive water jet machining, Ultrasonic machining their principles, equipment, effect of process parameters, applications, advantages and limitations.	
UNIT II - CHEMICAL AND ELECTRO CHEMICAL ENERGY BASED PROCESSES	**(9)**
Principles, equipments, effect of process parameters, applications, advantages and limitations of Chemical machining, Electro-chemical machining, Electro-chemical honing, Electro-chemical grinding, Electro chemical deburring.	
UNIT III - THERMO-ELECTRIC ENERGY BASED PROCESSES	**(9)**
Principles, equipments, effect of process parameters, applications, advantages and limitations of Electric discharge machining, Wire electric discharge machining, Laser beam machining, Plasma arc machining, Electron beam machining, Ion beam machining.	
UNIT IV - NANO FINISHING PROCESSES	**(9)**
Principles, equipments, effect of process parameters, applications, advantages and limitations of Abrasive flow machining – Chemo mechanical polishing, Magnetic abrasive finishing, Magneto rheological finishing, Magneto rheological abrasive flow finishing.	
UNIT V – HYBRID NON-TRADITIONAL MACHINING PROCESSES	**(9)**
Introduction - Various hybrid non-traditional machining processes, their working principles, equipments, effect of process parameters, applications, advantages and limitations. Selection and comparison of different non-traditional machining processes.	
TOTAL = 45 PERIODS	

TEXT BOOKS:

1. Adit han. M., "Unconventional Machining Processes", Atlantic, New Delhi, India, 2009. ISBN 13: 9788126910458
2. Ana nd Pandey, "Modern Machining Processes", Ane Books Pvt. Ltd., New Delhi, India, 2019.

REFERENCES:

1. Benedict, G.F., "Non-traditional Manufacturing Processes", Marcel Dekker Inc., New York 1987. ISBN-13: 978-0824773526.
2. Carl Sommer, "Non-Traditional Machining Handbook", Advance Publishing., United States, 2000, ISBN-13: 978-1575373256.
3. Golam Kibria, Bhattacharyya B. and Paulo Davim J., "Non-traditional Micromachining Processes: Fundamentals and Applications", Springer International Publishing., Switzerland, 2017, ISBN:978-3-319-52008-7.
4. Jagadeesha T., "Non-Traditional Machining Processes", I.K. International Publishing House Pvt. Ltd., New Delhi, India, 2017, ISBN-13: 978-9385909122.
5. Kapil Gupta, Neelesh K. Jain and Laubscher R.F., "Hybrid Machining Processes: Perspectives on Machining and Finishing", 1st edition, Springer International Publishing., Switzerland, 2016, ISBN- 13: 978-3319259208.

CO	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	
2		3											2	
3				3									2	
4		3											2	
5		2											2	
CO (W.A)	**3**	**2.7**		**3**									**2**	

22MEX04 - DESIGN CONCEPTS IN ENGINEERING

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To study the various design requirements and get acquainted with the processes involved in product development. • To study the design processes to develop a successful product. • To learn scientific approaches to provide design solutions. • Designing solution through relate the human needs and provide a solution. • To study the principles of material selection, costing and manufacturing in design.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Analyze the various design requirements and get acquainted with the processes involved in product development.	An	20%
CO2	Apply the design processes to develop a successful product.	Ap	20%
CO3	Apply scientific approaches to provide design solutions.	Ap	20%
CO4	Design solution through relate the human needs and provide a solution.	Cr	20%
CO5	Apply the principles of material selection, costing and manufacturing in design.	Ap	20%

UNIT I- DESIGN TERMINOLOGY	**(9)**
Definition-various methods and types of design-importance of product design-various design projects-morphology of design-requirements of a good design-design guidelines-design catalogs-codes and standards-design product and process cycles-bench marking.	
UNIT II - INTRODUCTION TO DESIGN PROCESSES	**(9)**
Basic modules in design process-scientific method and design method- identification, importance of problem - structured problem, real life problem- information gathering -customer requirements- Quality Function Deployment (QFD)- Detail design and engineering drawings-prototyping and testing-Design for X.	
UNIT III - CREATIVITY IN DESIGN	**(9)**
Creativity and problem solving-vertical and lateral thinking-invention, innovation, diffusion-psychological view, mental blocks- Creativity methods-brainstorming, mind map, concept map-Theory of innovative problem solving (TRIZ) –Axiomatic design.	
UNIT IV - HUMAN AND SOCIETAL ASPECTS IN PRODUCT DEVELOPMENT	**(9)**
Human factors in design, ergonomics, user friendly design-Aesthetics and visual aspects - environmental aspects-marketing aspects-team aspects-legal aspects-presentation aspects	

UNIT V – MATERIAL AND PROCESSES IN DESIGN	(9)
Material selection for performance characteristics of materials-selection for new design substitution for existing design-economics of materials-selection methods-recycling and material selection-types of manufacturing process, process systems-Design for Manufacture (DFM)-Design for Assembly (DFA).	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Dieter. G. N., Linda C. Schmidt, "Engineering Design", McGraw Hill, 2013.
2. Horenstein, M. N., Design Concepts for Engineers, Prentice Hall, 2010.

REFERENCES:

1. Edward B. Magrab, Satyandra K. Gupta, F. Patrick McCluskey and Peter A. Sandborn, "Integrated Product and Process Design and Development", CRC Press, 2009.
2. Sumesh Krishnan and MukulSukla, Concepts in Engineering Design, Notion Press, 2016.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3		1									3	
2	3		1										2	
3	2		3	1									2	
4		2	3		1								1	
5										1	2	2	1	
CO (W.A)	**2.3**	**2.5**	**2.3**	**2.0**	**1.0**					**1.0**	**2.0**	**2.0**	**1.8**	

22MEX05 DESIGN OF TRANSMISSION SYSTEMS

L	T	P	C
2	1	0	3

PREREQUISITE : 22MEC14

Course Objective:

- To understand and apply the fundamental design principles
- To analyze complex gear drive problems
- To design and draft gearbox layouts
- To evaluate mechanical power transmission systems
- To implement standards and regulations

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply fundamental design principles to calculate the parameters for various gear drives, belt drives, chain drives, clutches, and brakes.	Ap	20%
CO2	Analyze complex problems related to spur, helical, bevel and worm gear drives by considering factors like materials, loads, stresses and efficiency.	An	40%
CO3	Design the multistage gear box and draft the kinematic arrangement and ray diagram.	An/E	20%
CO4	Evaluate various mechanical power transmission systems, including belts, chains, gears, gearboxes, clutches, and brakes by using engineering principles and manufacturer data	E	20%
CO5	Implement standards, codes, and regulations in transmission system design.	U/Ap	Internal Assessment

UNIT I - DESIGN OF FLEXIBLE POWER TRANSMISSION SYSTEMS **(6+3)**

Design flat belt and V belt drive based on manufacturer's catalogue- design of transmission chains and sprockets. Introduction to timing belt and silent chain.

UNIT II - SPUR GEARS AND HELICAL GEARS **(6+3)**

Gear materials- design of straight tooth spur gear & Parallel axis helical gears based on speed ratio, number of teeth, Fatigue strength, Factor of safety, Strength and wear considerations. Forces on teeth-stresses on teeth-gear failures-Helical gear-Module-Normal and transverse, Equivalent number of teeth.

UNIT III - BEVEL AND WORM GEARS **(6+3)**

Straight bevel gear: Gear materials - tooth terminology - tooth forces and stresses – Design of straight bevel gears based on speed ratio, number of teeth, Fatigue strength, Factor of safety, Strength and wear considerations – Worm gear: Gear materials –tooth terminology, Thermal capacity, Forces and stresses, efficiency, design of worm gear drive by checking surface and bending stresses.

UNIT IV - DESIGN OF GEAR BOXES **(6+3)**

Gear boxes - speed selection - geometric progression - standard step ratio - ray diagram, kinematic layout - design of multistage multi speed constant mesh gear boxes. Introduction to automobile gear box design.

UNIT V - MOTION CONTROL: CLUTCHES AND BRAKES **(6+3)**

Clutches - types - materials - design of single plate, multi plate and cone clutches - brakes - types - friction materials – design of single block brake, simple band brake, and internal expanding brake. Introduction to Design of Disc brake.

TOTAL (L:30 +T:15) =45 PERIODS

Sl.No	Practice Titles	Unit
1 2 3	Flat belt and V belt drive Design of straight tooth spur gear Design of straight bevel gears	1 2 3

TEXTBOOKS:

1. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett "Mechanical Engineering Design", 10th ed., Tata McGraw-Hill, 2015
2. Bhandari V.B, "Design of Machine Elements", 4th ed., Tata McGraw-Hill Book Co, 2017

REFERENCES:

1. Jalaludeen S.Md, "Machine Design (Volume-2)", 4th ed., Anuradha Publications, Chennai, 2012
2. Robert C. Juvinall, Kurt M. Marshek, "Machine Component Design", Wiley India Pvt Ltd., 2016
3. Sharma P. C, Aggarwal D. K., "A Textbook of Machine Design" S K Kataria & Sons-New Delhi, 2013
4. Spotts M. F, Shoup T. E , Hornberger L.E , David O. Kazmer, "Design of Machine Elements", 8th ed., Pearson India, 2006
5. Sundararajamoorthy T. V, Shanmugam .N, "Machine Design", Anuradha Publications, Chennai, 200

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2		3											3	
3			3										3	
4			3										3	
5						2		2						
CO (W.A)	3	3	3			2		2					3	

22MEX06 - AUTOMOBILE ENGINEERING

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:

- To introduce the types of automobiles, structure and construction details
- To acquire knowledge on engine auxiliary system and ignition systems
- To know about the engine transmission systems
- To learn the working principle of steering, brakes and suspension systems
- To introduce the types of emissions in automobiles, emission control techniques and advanced technologies

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the working concept of cooling and lubrication system in internal combustion engines	Ap	30%
CO2	Apply the design concept in clutch, gear box and other transmission systems.	Ap	30%
CO3	Analyze the performance of steering, braking and suspension systems.	An	20%
CO4	Analyze the emission norms and safety systems in automobile.	An	20%
CO5	Seminar presentation in the recent technologies in automobiles	U	Internal Assessment

UNIT I - VEHICLE STRUCTURE AND ENGINE COMPONENTS (9)

Types of automobiles - vehicle construction and layouts - chassis - frame and body – Vehicle aerodynamics, resistances and moments - components of IC engines- their forms, functions and materials – cooling system - lubrication system.

UNIT II - ENGINE AUXILIARY SYSTEMS (9)

Fuel supply system, Simple Carburetor - electronically controlled gasoline injection system for SI engines - Mono point and multi point fuel injection system - electronically controlled diesel injection system - rotary distributor type, CRDI, unit injector system - Ignition system - battery coil ignition system, magneto coil ignition system, electronic coil ignition system (Transistorized coil ignition system, capacitive discharge ignition system) -Turbo charger - super charger - electronic engine management system

UNIT III - TRANSMISSION SYSTEMS (9)

Clutch - Types and construction - single plate, multi plate, diaphragm clutch - types of gear boxes - sliding mesh, constant mesh, synchromesh - gear shifting mechanism - overdrive – transfer box- fluid flywheel - torque converter - propeller shaft - slip joint - universal joint - differential - Hotchkiss drive and torque tube drive.

UNIT IV - STEERING, BRAKES AND SUSPENSION SYSTEMS	(9)
Principle of steering - steering geometry - steering linkages - steering gear box - power steering – Direct adaptive steering - brakes - types and construction - drum brake, disc brake, pneumatic braking system, hydraulic braking system, anti lock braking system (ABS) - types of front and rear axle - suspension system - types and construction - coil spring, leaf spring, stabilizer bars- air suspension -shock absorber	
UNIT V - EMISSION CONTROL, SAFETY SYSTEMS	**(9)**
Automobile emissions - standards - Control techniques - exhaust gas recirculation - 3 way catalytic converter - Safety standards for automobiles - seat belts - air bags -Electronic Brake Distribution (EBD) - Electronic Stability Program (ESP) - Traction Control System (TCS) - Global Positioning System (GPS) - Collision avoiding system, low tire pressure warning system, driver information system. Blind spot detection and warning.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Babu.A.K and Ajit Pal Singh, "Automobile Engineering", Ist ed., S.Chand Publications, 2014
2. Kirpal Singh, "Automobile Engineering Vol.I and 2", Standard Publishers, New Delhi, 2021

REFERENCES:

1. William H. Crouse and Donald L Anglin, "Automotive Mechanics", McGraw Hill Education (India) Private Limited, 10th Edition, 2017
2. Rajput.R.K, "A textbook Automobile Engineering" Laxmi Publishers, 3rd ed., New Delhi, 2018
3. Ramakrishna K, "Automobile Engineering", Prentice Hall India Learning Private Limited, 2012
4. Srinivasan.S, "Automotive Mechanics", 2nd ed., McGraw Hill Education (India) Private Limited, 2017
5. Jain K.K and Asthana.R.B, "Automobile Engineering", Ist ed., McGraw Hill Education Pvt. Ltd., 2017

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2												1	
2	2												1	
3		1												
4		1												
5										1				
CO (W.A)	2	1								1			1	

22MEX07 INDUSTRIAL LAYOUT DESIGN AND SAFETY

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To introduce the industrial facility layout design principles, process and material flow analysis and product and equipment analysis. • To learn the facilities layout design algorithms and selecting appropriate software. • To study the facilities layout problem modelling tools and algorithms for production, warehouse, and material handling. • To learn the safety planning and management principles in industries. • To learn the various safety management approaches in industries.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Analyze industrial facility layout design principles, process and material flow analysis and product and equipment analysis.	An	20%
CO2	Apply the engineering design problem approach to analyze products, select equipment and analyze space requirements and availability.	Ap	20%
CO3	Upgrade safety developmental programs by implementing safety procedures, arrangements, and performance measures.	Ap	20%
CO4	Evaluate safety performance by understanding accidents, occupational health, and industrial hygiene.	An	20%
CO5	Illustrate the various safety management approaches in industries.	An	20%

UNIT I- INTRODUCTION	**(9)**
Industrial Facility Layout: Definition, Types of Layout Problems, Engineering Design Problem Approach – Product Analysis, Equipment Selection, Personnel Requirement Analysis, Space Requirement and Availability – Process and Material Flow Analysis, Data Requirement for Layout Decisions, Tools for Presenting Layout Designs.	
UNIT II - FACILITIES LAYOUT DESIGN & ALGORITHMS	**(9)**
.Traditional Approaches to Facility Layout, Systematic Layout Planning, Special Considerations in Office Layout, Engineering Design Problem Approach, Code Compliance, OSHA, ADA Regulations, and Other Considerations in Facility Design – Algorithms for the Layout Problem, Construction Algorithms, Improvement Algorithms, Hybrid Algorithms, Layout Software (CRAFT, BLOCPLAN, PFAST, Layout-iQ, VIP-PLANOPT, Factory CAD, Factory FLOW, Plant Simulation)	
UNIT III - FACILITIES LAYOUT PROBLEM MODELS & ALGORITHMS	**(9)**
Models for the Layout Problem, Generic Modeling Tools, Models for the Single-Row Layout Problem, Models for the Multi row Layout Problem with Departments of Equal and Unequal Area – Material Handling, Principles, Types, Models for Material-Handling System Design – Storage and Warehousing, Warehouse Functions, Warehouse Design and Operation.	

UNIT IV - SAFETY PLANNING & MANAGEMENT	(9)
Introduction: Elements of Safety Programming, Safety Management. Upgrading Safety Developmental Programs: Safety Procedures, Arrangements and Performance Measures, Education, Training and Development in Safety. Safety Performance: An Overview of an Accident, Occupational Health and Industrial Hygiene. Understanding the Risks: Prevention of Accidents Involving Hazardous Substances. Indian Factories Act 1948 for Health and Safety. .	
UNIT V – APPROACHES IN SAFETY MANAGEMENT	**(9)**
Safeguarding against Common Potential Hazards: Trips, Slips and Falls, Preventing Electrocution, Static Electricity, Hazardous Energy Control. Specific Hazard Control Measures: Forklift Hazard Control, Tractor Hazard Control. Safe Handling and Storage: Material Handling, Compressed Gas Cylinders, Corrosive Substances, Hydrocarbons, Waste Drums and Containers.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS

1.Sunderesh S. Heragu, "Facilities Design", 3rd Edition, CRC Press Taylor & Francis Group, 2008.

2. L. M. Deshmukh, "Industrial Safety Management: Hazard Identification and Risk Control", Tata McGraw-Hill Publishing Co. Ltd., 2005.

REFERENCES:

1.EricTeicholz, "Facility Design and Management Handbook", Tata McGraw-Hill Publishing Co. Ltd., 2001.

2.James A. Tompkins, John A. White, Yavuz A. Bozer, and J. M. A. Tanchoco, "Facilities Planning", 4th Edition, John Wiley &Sons, 2010.

3.Matthew P. Stevens and Fred E. Meyers, "Manufacturing Facilities Design and Material Handling", 5th Edition, Purdue University Press, 2013.

4.CharlesD.Reese, Occupational Health and Safety Management: A Practical Approach, CRC Press, 2003.

5.JMaiti, Pradip Kumar Ray, Industrial Safety Management: 21st Century Perspectives of Asia, Springer, 2017.

6.Industrial Hazard and Safety Handbook: (Revised impressionby Ralph W King and John Magid | 24 September 2013

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	2	2										2	
2													2	
3													2	
4				2									2	
5						3		3	2	1	1	3	2	
CO (W.A)	1	2	2	2		3		3	2	1	1	3	2	

22MEX08 – MODERN ROBOTICS

L	T	P	C
3	0	0	3

PREREQUISITE :

Course Objective:

- To introduce definition, history of robotics and robot anatomy.
- To learn the simulation of robot kinematics
- To study the grasping and manipulation of robots.
- To study about mobile robot and manipulation.
- To study the applications of industrial, service, domestic robots.

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the definition, history of robotics and robot anatomy.	Ap	20%
CO2	Design and Develop the simulation of robot kinematics	An	20%
CO3	Optimize ethical knowledge in the grasping and manipulation of robots.	An	40%
CO4	Establish real time working about mobile robot and manipulation.	Ap	20%
CO5	Manipulate the applications of industrial, service, domestic robots.	An/ Cr	Internal Assessment

UNIT I - INTRODUCTION	(9)
Robot: Definition, History of Robotics, Robot Anatomy, Co-ordinate systems, types and classification, Configuration space and degrees of freedom of rigid bodies and robots, Configuration space topology and representation; configuration and velocity constraints; task space and workspace, Rigid-body motions, rotation matrices, angular velocities, and exponential coordinates of rotation, Homogeneous transformation matrices.	
UNIT II - SIMULATION OF ROBOT KINEMATICS	(9)
Robot kinematics, Forward and inverse kinematics (two three four degrees of freedom), Forward and inverse kinematics of velocity, Homogeneous transformation matrices, translation and rotation matrices Dennavit and Hartenberg (D-H) transformation, Dynamics of Open Chains, Trajectory Generation, motion planning, robot control: First- and second-order linear error dynamics, stability of a feedback control system. Sensors- Infrared, Temperature, Proximity, Ultrasonic, Gyroscope, Hall effect and Light sensor.	
UNIT III - GRASPING AND MANIPULATION OF ROBOTS	(9)
Kinematics of contact, contact types (rolling, sliding, and breaking), graphical methods for representing kinematic constraints in the plane, and form-closure grasping, Coulomb friction, friction cones, graphical methods for representing forces and torques in the plane, End effectors, grippers, types of gripper, gripper force analysis, and examples of manipulation and grasping.	

UNIT IV - MOBILE ROBOTS	(9)
Mobile robot, Wheeled Mobile Robots: Kinematic models of omnidirectional and non-holonomic wheeled mobile robots, Controllability, motion planning, feedback control of non-holonomic wheeled mobile robots; odometry for wheeled mobile robots; and mobile manipulation. Reference Trajectory generation, feed forward control. Mobile Robots applications and case studies on aerospace, medical, chemical industry, UAV's & UGV's triage and surveillance.	
UNIT V - APPLICATIONS OF ROBOTS	(9)
Application of robotic: industrial robots, Service robots, domestic and house hold robots, Medical robots, military robots, agricultural robots, space robots, Aerial robotics Role of robots in inspection, assembly, material handling, underwater, space and healthcare. Case studies on mobile manipulator, transportation and picking areas.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Modern Robotics: Mechanics, Planning, and Control, by Kevin M. Lynch , Frank C. Park , Cambridge University Press; 1st edition (25 May 2017), ISBN-10 : 110715
2. Modern Robotics: Mechanics, Systems and Control, by Julian Evans, Larsen and Keller Education (27 June 2019), ISBN-10 : 1641720751

REFERENCES:

1. Modern Robotics: Designs, Systems and Control, by Jared Kroff, Willford Press (18 June 2019)ISBN-10 : 1682856763
2. Advanced Technologies in Modern Robotic Applications, by ChenguangYang, Hongbin Ma, Mengyin Fu, Springer; Softcover reprint of the original 1st ed. 2016 edition (30 May 2018), ISBN - 10 : 981109263X
3. Modern Robotics: Building Versatile Machines, by Harry Henderson, Facts On File Inc; Illustrated edition (1 August 2006), ISBN-10 : 0816057451
4. Artificial Intelligence for Robotics, by Francis X. Govers, Packt Publishing Limited; Standard Edition (30 August 2018), ISBN-10 : 178883544I
5. Modern Robotics Hardcover by Lauren Barrett (Editor), Murphy & Moore Publishing (1 March 2022), ISBN-10 : 1639873732

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	
2					2									
3			3											
4												3		
5								3						
CO (W.A)	3		3		2			3				3	2	

22MEXTT - AUTOMOTIVE MATERIALS, COMPONENTS, DESIGN AND TESTING

L	T	P	C
2	0	2	3

PREREQUISITE : Nil

Course Objective:

- To analyze and prioritize functional requirements of engine components while critically assessing suitable materials for optimal performance
- To design cylinder and piston components
- To design connecting rod and crank shaft
- To design of flywheel and valve train
- To describe the Engine Testing cycles, Emission measurement technologies

	Course Outcomes The Student will be able to	Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply knowledge to select suitable materials for various engine components based on their functional requirements.	Ap	20%
CO2	Design the cylinder and piston components considering engineering principles and material properties.	C	30%
CO3	Apply analytical skills to design a connecting rod and crankshaft under different loading conditions.	C	30%
CO4	Design a flywheel and valve train design to meet specified performance criteria.	C	20%
CO5	Demostrate the engine testing procedures and current standards followed in India for engine testing.	U	Internal Assessment

UNIT – I FUNCTIONAL REQUIREMENTS OF ENGINE COMPONENTS AND SUITABLE MATERIALS **(6)**

Functional requirements of engine components – Piston, piston pin, cylinder liner, connecting rod, crank shaft, valves, spring, engine block, cylinder head, and flywheel. Suitable materials for engine components.

UNIT – II DESIGN OF CYLINDER AND PISTON COMPONENTS **(6)**

Design of cylinder, cylinder head, piston, piston rings and piston pin

UNIT – III DESIGN OF CONNECTING ROD AND CRANK SHAFT **(6)**

Design of connecting rod – Shank design – small end design – big end design – bolts design. Design of overhang crank shaft under bending and twisting – Crank pin design – Crank web design – Shaft design.

UNIT – IV DESIGN OF FLYWHEEL AND VALVE TRAIN **(6)**

Design of valve – inlet valve – exhaust valve - Valve springs – Camshafts – SOHC & DOHC– tappet – rocker arm. Determination of mass of flywheel for a given coefficient of fluctuation of speed. Design of flywheel - rim - hub – arm.

UNIT – V ENGINE TESTING **(6)**

Engine test cycles – Worldwide harmonized Light-duty vehicles Test Cycles ((WLTC) – World Harmonized Stationary Cycle (WHSC) – World Harmonized Vehicle Cycle (WHVC) – Nonroad Transient Cycle (NRTC) – ISO 8178. Dynamometer - Chassis dynamometer - transient dynamometer. Emission measurement technologies and instruments - NO_X – Smoke – Particulate matter – CO – CO_2 - HC.-Particle counter, Current Standards followed in India for Engine Testing.

EXPERIMENTS

1. Design and animate Piston Cylinder assembly and motion study using CAD software.
2. Design and simulate Connecting rod and crank shaft
3. Design flywheel and valve
4. Design and simulate Two Cylinder Engine assembly using CAD software.
5. Conduct the engine performance test
6. Conduct the emission test

TOTAL (L:30 + P:30) = 60 PERIODS

TEXT BOOKS:

1. Khurmi. R.S. & Gupta. J.K., "A text book of Machine Design", Eurasia Publishing House (Pvt) Ltd, 2001.
2. The Automotive Chassis: Volume 1: Components Design (Mechanical Engineering Series) by Giancarlo Genta and Lorenzo Morello | 24 December 2019

REFERENCES:

1. Hiroshima Yamagata, "The science and technology of materials in automotive engines", Woodhead Publishing Limited, Cambridge, England.
2. Jain.R.K, "Machine Design", Khanna Publishers, New Delhi, 2005
3. Manufacturing Automotive Components from Sustainable Natural Fiber Composites (SpringerBriefs in Materials) by Lobna A. Elseify, Mohamad Midani, et al. | 9 August 2021
4. Mechanical and Materials Engineering of Modern Structure and Component Design (Advanced Structured Materials Book 70) by Andreas Öchsner and Holm Altenbach | 6 June 2015
5. Advanced Technology for Design and Fabrication of Composite Materials and Structures: Applications to the Automotive, Marine, Aerospace and ... Applications of Fracture Mechanics) by George C. Sih, Alberto Carpinteri, et al. | 15 December 2010

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3													
2	3	3											3	
3	3	3											3	
4	3	3											3	
5							3	3						
CO (W.A)	3	3					3	3					3	

22MEX12 - CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY

L	T	P	C
3	0	0	3

PREREQUISITE :Nil

Course Objective:	• To determine the number of stages/plates required • To learn various advanced combustion technologies and its benefits • To learn the methods of using low carbon fuels and its significance • To analyze the advanced engine technologies • To apply advanced principles of drivetrain technology in diverse operational scenarios • To study the application of fuel cell technology in automotives

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply combustion technology principles to analyze and optimize Spark Ignition and Compression Ignition combustion processes.	Ap	20%
CO2	Evaluate and apply low carbon fuel technologies such as Alcohol Fuels, Methane, and Hydrogen for automotive applications.	E	20%
CO3	Apply advanced engine technologies in engine design and performance optimization.	Ap	30%
CO4	Analyze the design and performance challenges of hybrid and pure electric vehicles to propose solutions for efficiency improvements.	An	30%
CO5	Demonstrate the advancements and operational principles of fuel cell technology for automotive applications and their road map to market integration.	U	Internal Assessment

UNIT – I COMBUSTION TECHNOLOGY	**(9)**
Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts– Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.	
UNIT – II LOW CARBON FUEL TECHNOLOGY	**(9)**
Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward	
UNIT – III ADVANCED ENGINE TECHNOLOGY	**(9)**
Gasoline Direct Injection, Common Rail Direct Injection, Fixed Geometry Turbocharger, Variable Geometry Turbocharger (VGT), Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, Variable valve timing (VVT), Intelligent Cylinder De-activation, After Treatment Technologies, Electric Exhaust Gas Recirculation, recent Engine Management System architecture	

UNIT – IV ADVANCED DRIVE TRAIN TECHNOLOGY	(9)
Automatic Planetary Gearbox, Torque Converter, Fluid Coupling, Continuously Variable Transmission (CVT), Automated Manual Transmission (AMT), Dual clutch transmission (DCT)/ Direct Shift Gearbox (DSG), Intelligent Manual Transmission (IMT) / Clutch-less Transmission, Limited Slip Differential	
UNIT – V FUEL CELL TECHNOLOGY	**(9)**
Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004
2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6, SPRINGER

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998
4. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
5. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2	3	3											3	
3	3												3	
4	3	3											3	
5							3							
CO (W.A)	3	3					3						3	

22MEX13 -RENEWABLE POWERED OFF HIGHWAY VEHICLES AND EMISSION CONTROL TECHNOLOGY

	L	T	P	C
	3	0	0	3

PREREQUISITE :Nil

Course Objective:	• To study the low and zero carbon fuels suitability and methods of use in off-road vehicles • To learn and understand the green energy production methodologies and its use in off-road vehicle categories • To learn various fuel cell types and its suitability in off-highway vehicles applications • To illustrate the impact of in-cylinder technologies on engine out emissions control • To study the existing after-treatment technologies used in off-highway vehicle applications

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Analyze the suitability and technologies of low and zero carbon fuels for powering off-road vehicles.	An	20%
CO2	Apply solar and hydrogen technologies to develop green energy solutions for off-highway vehicles.	Ap	30%
CO3	Evaluate the design and application of fuel cells for off-highway vehicle power systems.	E	30%
CO4	Analyze the effectiveness of in-cylinder treatment technologies in reducing engine emissions.	An	20%
CO5	Demonstrate the principles and applications of after-treatment technologies in emission control for off-highway vehicles.	U	Internal Assessment

UNIT – I LOW AND ZERO CARBON FUELS POWERED OFF-HIGHWAY VEHICLES	**(9)**
Ethanol, Methanol, Butanol, Biodiesel, Compressed natural gas, liquefied natural gas, Dimethyl ether, Polyoxymethylene Dimethyl Ether, Ammonia and Hydrogen Fuels suitability, methods, and technologies for powering off-road vehicles.	
UNIT – II GREEN ENERGY POWERED OFF-HIGHWAY VEHICLES	**(9)**
Solar Technology for Green Electricity, Green Electricity for Hydrogen Production, Hydrogen Smart Grid Technologies, Hydrogen to ICE powered vehicles, Hydrogen to Fuel Cell Powered Vehicles.	
UNIT – III FUEL CELL POWERED OFF-HIGHWAY VEHICLES	**(9)**
Fuel Cell, Types, Applications, Fuel Cell Requirement, Sizing and Design for Off-Highway applications, Merits and Demerits, Pathway to overcome the limitations. Scope of the fuel cell research on Off-road vehicle applications.	
UNIT – IV IN-CYLINDER TREATMENT TECHNOLOGIES	**(9)**
Low temperature Combustion Modes - Homogeneous Charge Compression Ignition, Premixed- Charge Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition, Water Injection Technologies.	

UNIT – V AFTER TREATMENT TECHNOLOGIES	(9)
Diesel Oxidation Catalyst, Diesel Particulate Filter, Selective Catalytic Reduction, Ammonia slip / clean up catalyst. CO2 absorption techniques, Waste Heat Recovery and Organic Rankine Cycle.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. John Twidell, and Tony Weir. Renewable Energy Sources – 3rd Edition 2015
2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines.

REFERENCES:

1. Daniel J Holt. Fuel Cell Powered Vehicles: Automotive Technology of the Future. Society of Automotive Engineers, 2001 - Technology & Engineering,
2. W. Addy Majewski, Magdi K. Khair. Diesel Emissions and Their Control.
3. Toward Zero Carbon: The Chicago Central Area DeCarbonization Plan by Adrian Smith and Gordon Gill | 1 June 2011
4. Transportation in a Net Zero World: Transitioning Towards Low Carbon Public Transport (Green Energy and Technology) by Kathryn G. Logan, Astley Hastings, et al. | 7 April 2022
5. The Political Economy of Low Carbon Transformation: Breaking the habits of capitalism (Routledge Studies in Low Carbon Development) by Harold Wilhite | 21 December 2017

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3											3	
2	3												3	
3	3	3											3	
4	3	3											3	
5							3							
CO (W.A)	3	3					3						3	

22MEX14 - VEHICLE HEALTH MONITORING, MAINTENANCE AND SAFETY

	L	T	P	C
	3	0	0	3

PREREQUISITE :Nil

Course Objective:	• To learn the fundamentals of vehicle maintenance, including diagnostics, service intervals, and international safety standards • To acquire knowledge on vehicle maintenance principles and advanced diagnostic technologies to service power train and vehicle systems. • To analyze the stresses acting on the temporary and permanent joints • To apply machine learning techniques to improve electronic fuel injection and engine management systems • To study and understand the simulation of safety concepts

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply knowledge of vehicle maintenance principles and advanced diagnostic technologies to service power train and vehicle systems	Ap	40%
CO2	Analyze and implement maintenance strategies for vehicle systems, including power train components and vehicle systems	An	20%
CO3	Analyze safety concepts, including active and passive safety systems, collision warning systems, and object detection mechanisms	An	20%
CO4	Apply machine learning techniques to enhance electronic fuel injection and engine management services	Ap	20%
CO5	Implement maintenance practices for ensuring optimal vehicle handling and safety	U/Ap	Internal Assessment

UNIT – I INTRODUCTION	**(9)**
`Need for maintenance – importance, classification of maintenance work-basic problem diagnosis. maintenance of vehicle systems – power pack, tyres, safety systems. scheduled maintenance services – service intervals – on-board diagnostics, computerized engine analyzer study and practice- obd and scan tools; Importance of advanced diagnostic technologies, Overview of international vehicle safety standards and regulations	
UNIT – II POWERTRAIN MAINTENANCE	**(9)**
Exhaust emission test of petrol and diesel engine; - Electronic fuel injection and engine management service - fault diagnosis- OBD-III and scan tool, identifying DTC and servicing emission controls, Maintenance of Batteries, Starting System, Charging System and Body Electrical - Application of Machine Learning in Electronic Fuel Injection and Engine Management Service.	
UNIT – III VEHICLE SYSTEM MAINTENANCE	**(9)**
Clutch- adjustment and service, Maintenance and Service of Hydraulic brake, Bleeding of brakes, Checking ABS and components. Maintenance and Service of McPherson strut, coil spring. tyre wear, measurement of read depth and tyre rotation, Smart tyre wear monitoring and management systems Computerized wheel balancing & wheel alignment, Maintenance and Service of steering linkage, steering column, Rack and pinion steering	

UNIT – IV VEHICLE SAFETY	(9)
Concepts of vehicle safety -Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, air bags, electronic system for activating air bags, bumper design for safety, Active Safety - ABS, EBD, CSC, Traction control system, Modern electronic features in vehicles like tyre pressure monitoring, Automatic headlamp ON, Rain sensing wipers. Cybersecurity measures for vehicle safety and data protection	
UNIT – V SIMULATION OF SAFETY CONCEPTS	**(9)**
Active safety: driving safety, conditional safety, perceptibility safety, operating safety passive safety: exterior safety, interior safety, deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact. Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system Interactions.	
	TOTAL 45 PERIODS

TEXT BOOK:

1. 5th Edition, "Advanced Automotive Fault Diagnosis Automotive Technology: Vehicle Maintenance and Repair" By Tom Denton
2. Safety Management System and Documentation Training Programme Handbook by S. V. Paul ISBN: 9788123923444

REFERENCES:

1. Ed May, "Automotive Mechanics Volume One" and Two, Mc Graw Hill Publications, Tenth edition, 2018
2. Bosch Automotive Handbook, Tenth Edition, 2018
3. Jack Erjavek, "A systems approach to Automotive Technology", Cengage Learning, 5th Edition, 2012
4. William H. Crouse and Donald L. Anglin, "Automotive Mechanics", Tata McGraw Hill, 10thEdition, 2004.
5. Vehicle Service Manuals of Reputed Indian Manufacturers

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	
2		2											3	
3		2											3	
4	3													
5						2		2				2		2
CO (W.A)	3	2	2			2		2				2	3	2

22MEX15 - CAE AND CFD APPROACH IN FUTURE MOBILITY

	L	T	P	C
	3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To study the use of computer in mobility software or mobility. • To study the concepts computer aided design and rapid prototyping • To introduce the basic concepts of the finite elements methods. • To introduce basics and fundamental of the computational fluid dynamics • To introduce Turbulence Modeling and various simulation techniques

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the concepts of computational fluid dynamics in mobility engineering.	Ap	30%
CO2	Apply the modeling and discretization technique in various mechanical elements.	Ap	30%
CO3	Analyze the durability, reliability and crash analysis	An	20%
CO4	Analyze the basic concept of the Computer Aided Engineering / Computational Fluid Dynamics	An	20%
CO5	Develop the computer aided design and model in rapid prototyping.	Ap	Internal Assessment

UNIT I - COMPUTER AIDED ENGINEERING AND COMPUTATIONAL FLUID DYNAMICS	**(9)**
Introduction to use of computer in Mobility Product Life Cycle, Software for mobility. Introduction to design process and role of computers in the design process, use of modern computational tools used for design and analysis, Concept of modeling and simulation. CFD as a design and research tool, Applications of CFD in mobility engineering	
UNIT II - APPLICATIONS OF COMPUTER AIDED ENGINEERING	**(9)**
Computational Fluid Dynamics – Introduction three dimensional of fluid dynamics, equilibrium equation for a fluid conversation. Injection moulding of plastics simplification of mould geometry for FEA material model. Simulation for manufacturing process like casting and sheet metal applications. Durability analysis, reliability, crash analysis. Noise vibration and hardness NVH analysis.	
UNIT III - FINITE ELEMENT ANALYSIS	**(9)**
Basic Concept of Finite Element Method, Ritz and Rayleigh Ritz methods, Method of weighed residuals, Galerkin method. Governing differential equations of one and two dimensional problems, One Dimensional Second Order Equations – Discretization – Linear and Higher order Elements – Interpolation and shape functions, Derivation of Shape functions and Stiffness matrices and force vectors-Assembly of Matrices - Solution of static problems and case studies in stress analysis of mechanical components using 2D and 3D elements	

UNIT IV - COMPUTATIONAL FLUID DYNAMICS	(9)
CFD vs. experimentation; continuity, Navier-stokes and energy equations; modeling and discretization techniques; basic steps in CFD computation various simplifications, Dimensionless equations and parameters, Incompressible inviscid flows, Source panel method, and Vortex panel method. Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching. 3-D structured and unstructured grid generation, mesh smoothing and sensitivity checks. Different types of codes and grids used for CFD calculations.	
UNIT V - PROBLEM SOLVING USING CFD	**(9)**
Turbulence Modeling, different turbulent modeling scheme. Incompressible Viscous Flows, Applications to internal flows and boundary layer flows. Eddy viscosity and non-eddy viscosity models; Vehicle Aerodynamic Simulation Wind tunnel and on-road simulation of vehicles; Simulation of Ahmed and Windsor bodies; Vorticity based grid-free simulation technique; simulation in climatic and acoustic wind tunnels; velocity vector and pressure contour simulation	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Computational Fluid Dynamics: A Practical Approach by Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Butterworth – Heinemann Ltd, Second Edition, 2012.
2. Applied Computational Fluid Dynamics by S. C. Gupta, Wiley publisher, 2019

REFERENCES:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Groover, M. P., CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education,
3. 2008
4. TirupathiR.Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in
5. Engineering", International Edition, Pearson Education Limited, 2014.
6. Dhanaraj. R and Prabhakaran Nair. K, "Finite Element Analysis", Oxford Publications, 2015.
7. Versteeg, H.K., and Malalasekera, W.,"An Introduction to Computational Fluid Dynamics": The finite volume Method, Pearson Education, 2014

Mapping of COs with POs / PSOs

	POs												PSOs	
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2													
2	2													
3		**1**												**1**
4		**1**												**1**
5						**1**								
CO (W.A)	**2**	**1**				**1**								**1**

22MEX16 -HYBRID AND ELECTRIC VEHICLE TECHNOLOGY

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To introduce the concept of hybrid and electric drive trains. • To elaborate on the types and utilization of hybrid and electric drive trains. • To expose on different types of AC and DC drives for electric vehicles. • To learn and utilize different types of energy storage systems • To introduce concept of energy management strategies and drive sizing

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Analyze the performance and power source characterization of hybrid and electric vehicles in relation to their impact on energy supplies.	An	20%
CO2	Apply power flow control techniques to optimize fuel efficiency in hybrid and electric drive-train topologies.	Ap	20%
CO3	Implement and control AC and DC motor drives in hybrid and electric vehicles to enhance drive system efficiency.	Ap	40%
CO4	Analyze the performance and hybridization of different energy storage devices in hybrid and electric vehicles.	An	20%
CO5	Explain the historical development, social, and environmental significance of hybrid and electric vehicles.	U	Internal Assessment

UNIT I : INTRODUCTION TO HYBRID AND ELECTRIC VEHICLES	**(9)**
Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.	
UNIT II : HYBRID ELECTRIC DRIVE TRAINS	**(9)**
Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	
UNIT III : CONTROL OF AC & DC DRIVES	**(9)**
Introduction to electric components used in hybrid and electric vehicles, Configuration, and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency.	

UNIT IV : ENERGY STORAGE	(9)
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices	
UNIT V : DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES	**(9)**
Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification, and comparison of energy management strategies, Implementation issues.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Iqbal Husain, - Electric and Hybrid Vehicles: Design Fundamentalsll, Third Edition, 2021
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

REFERENCES:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. R and D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley &
3. Sons, 1998
4. Hybrid, Electric and Fuel-Cell Vehicles, International Edition by Jack Erjavec June 2012
5. Energy Management in Hybrid Electric Vehicles using Co-Simulation by Christian Paar11 February 2011
6. Hybrid Electric Vehicle Design and Control: Intelligent Omnidirectional Hybrids (MECHANICAL ENGINEERING) by YangshengXu , Jingyu Yan, et al. 16 December 2013

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3											3	
2	3												3	
3	3												3	
4	3	3											3	
5							3							
CO (W.A)	3	3					3						3	

22MEX17 - THERMAL MANAGEMENT OF BATTERIES AND FUEL CELLS

	L	T	P	C
	3	0	0	3

PREREQUISITE :

Course Objective:

- To study the working principle of Li-ion Batteries and Battery Packs.
- To learn the thermal management system in Battery modules.
- To develop the different case studies in Battery Thermal Management System.
- To learn the working principle of Fuel Cells and cooling methods.
- To learn the inside components of Thermal Management Systems in various famous Electric and Fuel Cell Electric Vehicles.

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply knowledge of Li-ion battery chemistry, formats, and management systems to optimize battery performance and longevity.	Ap	20%
CO2	Apply thermal management techniques to optimize battery performance in electric vehicles.	Ap	20%
CO3	Evaluate the effectiveness of different cooling methods in battery thermal management systems.	E	30%
CO4	Analyze the thermal management requirements and solutions for fuel cell systems in electric vehicles.	An	30%
CO5	Demonstrate the configuration and characteristics of battery management systems in advanced batteries.	U	Internal Assessment

UNIT I : ADVANCED BATTERIES (9)

Li-ion Batteries- chemistry, different formats, operating areas, efficiency, aging. Battery Management System- Configuration, Characteristics. Tesla Model S-18650 Cell specifications, P85 Battery Pack mechanical structure, Texas Instruments BMS. Super capacitors Vs batteries. Diamond battery concepts.

UNIT II : THERMAL MANAGEMENT IN BATTERIES (9)

Thermal Management Systems- impact, Types- Air, Liquid, Direct refrigerant, Heat pipe, Thermo Electric, Phase Change Material (PCM) Cooling methods. Solid-liquid PCM Types- Organic, Inorganic, Eutectics. PCM Thermal properties and applications. Tesla Model-S Battery Module- bonding techniques, thermal management.

UNIT III : BATTERY THERMAL MANAGEMENT CASE STUDIES (9)

EV Battery Cooling- challenges and solutions. Heat Exchanger Design and Optimization Model for EV Batteries using PCMs- system set up, selection of PCMs. Chevrolet Volt Model Battery Thermal Management System- Case study. Modeling Liquid Cooling of a Li-Ion Battery Pack with COMSOL Multi physics- simulation concepts

UNIT IV : THERMAL MANAGEMENT IN FUEL CELLS	(9)
Fuel Cells- operating principle, hydrogen-air fuel cell system characteristics, other fuel cell technologies, polarization curves, applications. Fuel cell thermal management- basic model, energy balance, governing equations, characteristic curve, sizing, cooling methods, advantages, restrictions.	
UNIT V : FUEL CELL THERMAL MANAGEMENT CASE STUDIES	**(9)**
Fuel cell system- balance of plant- components required. Fuel cell power plant sizing problems- Fuel Cell Electric Vehicle Fuel economy calculations-Battery EVs Vs Fuel Cell EVs. Toyota Mirai FCV- Operating principle, High pressure hydrogen tank, Boost convertor, NiMH Battery, Internal circulation system, Hydrogen refueling- Case studies.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Ibrahim Dinçer, Halil S. Hamut, and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", Wiley, 2017.
2. Jiuchun Jiang and Caiping Zhang, "Fundamentals and applications of Lithium-Ion batteries in Electric Drive Vehicles", Wiley, 2015.
3. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles-Fundamentals, Theory, and Design", CRC Press, 2005.
4. John G. Hayes and G. Abas Goodarzi, "Electric Powertrain", Wiley, 2018
5. Davide Andrea, "Battery Management Systems for Large Lithium-Ion Battery Packs" ARTECH House, 2010.

REFERENCES:

1. Nag.P.K, "Engineering Thermodynamics", 5th Edition, Tata McGraw Hill Education, New Delhi, 2013.
2. "Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK
3. Younes Shabany," Heat Transfer: Thermal Management of Electronics Hardcover" 2010, CRC Press.
4. T. Yomi Obidi, "Thermal Management in Automotive applications", 2015, SAE International.
5. Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", 1998, Mc Graw-Hill

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2	3												3	
3	3	3											3	
4	3	3											3	
5							3							
CO (W.A)	3	3					3						3	

22MEX18 SMART MOBILITY AND INTELLIGENT VEHICLES

	L	T	P	C
	3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To introduce students to the various technologies and systems used to implement smart mobility and intelligent vehicles • To learn basics of radar technology and systems, ultrasonic sonar systems, LIDAR sensor technology and systems and other sensors for automobile vision system • To learn basic control system theory applied to autonomous automobiles • To produce overall impact of automating like various driving functions, connecting the automobile to sources of information that assist with a task • To allow the automobile to make autonomous intelligent decisions concerning future actions of the vehicle that potentially impact the safety of the occupants through connected car & autonomous vehicle technology

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the concept of cyber-physical control systems and their application to collision avoidance and autonomous vehicles	Ap	20%
CO2	Apply the concept of remote sensing and the types of sensor technology needed to implement remote sensing	An	30%
CO3	Apply the concept of fully autonomous vehicles.	Ap	30%
CO4	Apply basic concepts of wireless communications and wireless data networks	Ap	20%
CO5	Integrate the connected vehicle and its role in automated vehicles	C	Internal assessment

UNIT I- INTRODUCTION TO AUTOMATED, CONNECTED, AND INTELLIGENT VEHICLES	**(9)**
Concept of automotive electronics, electronics overview, history & evolution, infotainment, body, chassis, and powertrain electronics, introduction to automated, connected, and intelligent vehicles. case studies: automated, connected, and intelligent vehicles.	
UNIT II - SENSOR TECHNOLOGY FOR SMART MOBILITY	**(9)**
Basics of radar technology and systems, ultrasonic sonar systems, lidar sensor technology and systems, camera technology, night vision technology, other sensors, use of sensor data fusion, integration of sensor data to on-board control systems.	
UNIT III - CONNECTED AUTONOMOUS VEHICLE	**(9)**
Concepts of autonomous vehicles, basic control system theory applied to automobiles, overview of the operation of ECUs, basic cyber-physical system theory and autonomous vehicles, role of surroundings sensing systems and autonomy, role of wireless data networks and autonomy.	
UNIT IV - VEHICLE WIRELESS TECHNOLOGY & NETWORKING	**(9)**
Wireless system block diagram and overview of components, transmission systems – modulation/encoding, receiver system concepts– demodulation/decoding, wireless networking and applications to vehicle autonomy, basics of computer networking – the internet of things, wireless networking fundamentals, integration of wireless networking and on-board vehicle networks.	

UNIT V – CONNECTED CAR & AUTONOMOUS VEHICLE TECHNOLOGY	(9)
Connectivity fundamentals, navigation and other applications, vehicle-to-vehicle technology and applications, vehicle-to-roadside and vehicle-to-infrastructure applications, autonomous vehicles - driverless car technology, moral, legal, roadblock issues, technical issues, security issues.	

TEXT BOOKS

1. "Intelligent transportation systems and connected and automated vehicles", 2016, transportation research board
2. Radovan miucic, "connected vehicles: intelligent transportation systems", 2019, springer

REFERENCES:

1. Tom denton, "automobile electrical and electronic systems, roultedge", taylor & francis group,5th edition,2018.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3													
2		3											1	
3	3													
4	3												1	
5										2		2		
CO (W.A)	3	3								2		2	1	

22MEX21-TURBO MACHINES

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:

- To study the energy transfer in rotor and stator parts of the turbo machines.
- To study the function of various elements of centrifugal fans and blowers.
- To evaluating the working and performance of centrifugal compressor
- To analyzing flow behavior and flow losses in axial flow compressor.
- To study the types and working of axial and radial flow turbines.

	Course Outcomes The Student will be able to	Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the principles of energy transfer in rotor and stator parts of turbo machines.	Ap	30 %
CO2	Analyze the flow behavior and flow losses in axial flow compressors.	An	20 %
CO3	Evaluate the working and performance of centrifugal compressors.	Ap	30 %
CO4	Justify the functions of various elements in centrifugal fans and blowers.	Ap/C	20 %
CO5	Develop teamwork and collaboration skills through group-based on the turbo machines assignments and peer reviews.	Ap/An	Internal Assessment

UNIT I - WORKING PRINCIPLES	**(9)**
Classification of Turbo machines. Energy transfer between fluid and rotor - Euler equation and its interpretation. Velocity triangles. Efficiencies in Compressor and Turbine stages. Degree of reaction. Dimensionless parameters for Turbo machines.	
UNIT II - CENTRIFUGAL FANS AND BLOWERS	**(9)**
Types – components – working. Flow analysis in impeller blades-volute and diffusers. Velocity triangles - h-s diagram. Stage parameters in fans and blowers. Performance characteristic curves – various losses. Fan – bearings, drives and noise.	
UNIT III - CENTRIFUGAL COMPRESSOR	**(9)**
Components - blade types. Velocity triangles - h-s diagram, stage work. Slip factor and Degree of Reaction. Performance characteristics and various losses. Geometry and performance calculation.	
UNIT IV - AXIAL FLOW COMPRESSOR	**(9)**
Construction details. Work done factor. Velocity triangles - h-s diagram, stage work. Work done factor. Performance characteristics, efficiency and stage losses – Stalling and Surging. Free and Forced vortex flow.	
UNIT V – AXIAL AND RADIAL FLOW TURBINES	**(9)**
Axial flow turbines - Types – Elements - Stage velocity diagrams - h-s diagram, stage work - impulse and reaction stages. Compounding of turbines. Performance coefficients and losses. Radial flow turbines: Types – Elements - Stage velocity diagrams - h-s diagram, stage work Performance coefficients and losses.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Ganesan, V., "Gas Turbines", 3rd Edition, Tata McGraw Hill, 2011. .
2. Yahya, S.M., "Turbines, Compressor and Fans", 4th Edition, Tata McGraw Hill, 2011.

REFERENCES:

1. Dixon, S.L., "Fluid Mechanics and Thermodynamics of Turbomachinery", 7th Edition, ButterworthHeinemann, 2014.
2. Gopalakrishnan. G and Prithvi Raj. D," A Treatise on Turbomachines", Scitech Publications (India) Pvt. Ltd., 2nd Edition, 2008.
3. Lewis, R.I., "Turbomachinery Performance Analysis" 1st Edition, Arnold Publisher, 1996.
4. Saravanamutto, Rogers, Cohen, Straznicky., "Gas Turbine Theory" 6th Edition, Pearson Education Ltd, 2009.
5. Venkanna, B.K., "Fundamentals of Turbomachinery", PHI Learning Pvt. Ltd., 2009.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2		3											3	
3	3												3	
4	3												3	
5	3								1	1			3	
CO (W.A)	3	3							1	1			3	

22MEX22 - ADVANCED INTERNAL COMBUSTION ENGINEERING

	L	T	P	C
	3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To study the working of Gasoline fuel `injection systems and SI combustion. • To study the working of Diesel fuel injection systems and CI combustion • To Identifying the source and measure it; explain the mechanism of emission formation and control methods. • To study the Selecting alternative fuel resources and its utilization techniques in IC engines. • To study the advanced combustion modes and future power train systems.

	Course Outcomes The Student will be able to	**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the working concept of Gasoline fuel injection systems in SI combustion.	Ap	30%
CO2	Apply the working concept of Diesel fuel injection systems diesel cycle.	Ap	30%
CO3	Analyze the performance of alternative fuels and utilization techniques in IC engines.	An	20%
CO4	Analyze the characteristics of Fuel Cells in automobiles	An	20%
CO5	Formulate the different advanced combustion modes and future power train systems.	U	Internal Assessment

UNIT I - SPARK IGNITION ENGINES	**(9)**
Mixture requirements – Fuel injection systems – Mono-point, Multipoint & Direct injection -Stages of combustion – Normal and Abnormal combustion, Spark Knock, Factors affecting knock, Combustion chambers.	
UNIT II - COMPRESSION IGNITION ENGINES	**(9)**
Diesel Fuel Injection Systems – Mechanical and Common Rail Direct Injection Systems - Stages of combustion – Knocking – Factors affecting knock –Direct and Indirect injection systems –Fuel Spray behaviour – Spray structure and spray penetration – Air motion - Combustion chambers – Turbo charging – Waste Gate, Variable Geometry turbochargers.	
UNIT III - EMISSION FORMATION AND CONTROL	**(9)**
Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling emissions – In-cylinder treatments – After treatment systems – Three Way Catalytic converter, Selective Catalytic Reduction, De-NOx Catalyst, Diesel Oxidation Catalyst and Particulate Traps – Methods of emission measurement – Emission norms and Driving cycles.	

UNIT IV - ALTERNATIVE FUELS	(9)
Alcohol Fuels, Hydrogen – production, storage - Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel - Properties, Suitability, Merits and Demerits – Utilization Methods - Engine Modifications.	
UNIT V - ALTERNATE COMBUSTION AND POWER TRAIN SYSTEM	**(9)**
Low Temperature Combustion - Homogeneous charge compression ignition (HCCI) – Reactivity Controlled Compression Ignition (RCCI) – Gasoline Compression Ignition – Spark Assisted HCCI - Hybrid Electric and Electric Vehicles –- Fuel Cells.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. V. Ganesan, "Internal Combustion Engines", V Edition, Tata McGraw Hill, 2012.
2. John B. Heywood, "Internal Combustion Engines Fundamentals", McGraw-Hill, 2009.

REFERENCES:

1. B.P. Pundir, "IC Engines Combustion & Emission", Narosa Publishing House, 2014.
2. Duffy Smith, "Auto Fuel Systems", The Good Heart Wilcox Company, Inc., 2003.
3. EranSher, Handbook of Air Pollution from Internal Combustion Engines: Pollutant Formation and Control, Academic Press, 1998.
4. K.K. Ramalingam, "Internal Combustion Engine Fundamentals", SciTech Publications, 2011.
5. R.B. Mathur and R.P. Sharma, "Internal Combustion Engines", Dhanpat Rai& Sons, 2007

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2												1	
2	2												1	
3		1												
4		1												
5								1						
CO (W.A)	2	1						1					1	

22MEX23- GAS DYNAMICS AND JET PROPULSION

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To study the fundamentals of compressible flow concepts and the use of gas tables. • To learn the compressible flow behaviour in constant area ducts • To study the development of shock waves and its effects • To study the types of jet engines and their performance parameters • To learn the types of rocket engines and their performance parameters.

	Course Outcomes The Student will be able to	**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the fundamentals of compressible flow concepts and the use of gas tables	Ap	20%
CO2	Analyze the compressible flow behaviour in constant area ducts	An	20%
CO3	Evaluate the development of shock waves and its effects	An	20%
CO4	Analyze the ethical implications and responsibilities associated with the design, development, and operation of compressible fluid flow systems and propulsion technologies.	An	20%
CO5	Classify the rocket engines and their performance parameters.	Ap	20%

UNIT I - BASIC CONCEPTS AND ISENTROPIC FLOWS	**(9)**
Energy and momentum equations of compressible fluid flows, Concepts of compressible flow – Mach waves and Mach cone. Flow regimes, effect of Mach number on compressibility. Stagnation, static, critical properties and their interrelationship. Isentropic flow and its relations. Isentropic flow through variable area ducts – nozzles and diffusers. Use of Gas tables.	
UNIT II - COMPRESSIBLE FLOW THROUGH DUCTS	**(9)**
Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties. Choking. Isothermal flow with friction. Use of Gas tables.	
UNIT III - NORMAL AND OBLIQUE SHOCKS	**(9)**
Governing equations – Rankine - Hugoniot Relation. Variation of flow parameters across the normal and oblique shocks. Prandtl – Meyer expansion and relation. Use of Gas tables.	
UNIT IV - JET PROPULSION	**(9)**
Theory of jet propulsion – thrust equation – Performance parameters - thrust, power and efficiency. Operation, cycle analysis and performance of ram jet, turbojet, turbofan, turbo prop and pulse jet engines.	
UNIT V – SPACE PROPULSION	**(9)**
Types of rocket engines and propellants. Characteristic velocity – thrust equation. Theory of single and multistage rocket propulsion. Liquid fuel feeding systems. Solid propellant geometries. Orbital and escape velocity. Rocket performance calculations.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Anderson, J.D., "Modern Compressible flow", Third Edition, McGraw Hill, 2003.
2. S.M.Yahya, "Fundamentals of Compressible Flow with Aircraft and Rocket propulsion", New Age International (P) Limited, 4th Edition, 2012.

REFERENCES:

1. R. D. Zucker and O Biblarz, "Fundamentals of Gas Dynamics", 2nd edition, Wiley, 2011. .
2. Balachandran. P., "Fundamentals of Compressible Fluid Dynamics", Prentice-Hall of India, 2007.
3. Radhakrishnan. E., "Gas Dynamics", Printice Hall of India, 2006.
4. Hill and Peterson, "Mechanics and Thermodynamics of Propulsion", Addison – Wesley, 1965.
5. Babu, V., "Fundamentals of Compressible Flow", CRC Press, 1st Edition, 2008

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	1
2		3	3										2	1
3													2	1
4								3					2	1
5												3	2	1
CO (W.A)	3	3	3				3						3	3

22MEX24 REFRIGERATION AND AIR CONDITIONING

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:

- To introduce the refrigerants and refrigeration cycles
- To know the working principles of vapour compression and vapour absorption refrigeration systems.
- To acquire knowledge on non-conventional refrigeration systems.
- To acquire knowledge on Air conditioning systems and their components
- To get exposure on load estimation in
- Refrigeration and air conditioning systems

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Calculate the performance and efficiency of simple vapor compression, absorption system and other non-conventional refrigeration systems.	Ap	20%
CO2	Analyze the different types of refrigeration cycles and determine the most suitable refrigerant for each application.	An	40%
CO3	Analyze the working principle of various air conditioning systems and select the most appropriate systems for specific applications, incorporating noise control methods.	An	20%
CO4	Estimate cooling and heating loads for various applications, including the design and maintenance of cold storage and domestic refrigerators.	An	20%
CO5	Involve in an independent study as a team and make effective oral presentation on Refrigeration and Air Conditioning Systems.	U	Internal Assessment

UNIT I : AIR REFRIGERATION CYCLES AND REFRIGERANTS	(9)
Refrigeration - systems, Coefficient of Performance - Reversed Carnot cycle - reversed Brayton cycle - Refrigerants - introduction, classification - primary refrigerants - designation - properties and uses of commonly used refrigerants - comparison and application of refrigerants – Leak detection.	
UNIT II - VAPOUR COMPRESSION AND ABSORPTION REFRIGERATION SYSTEMS	(9)
Simple vapour compression system - T-s diagrams - P-h chart - factors affecting the performance - actual vapour compression cycle - volumetric efficiency - methods of improving simple saturation cycle - Simple vapour absorption system - practical vapour absorption system - COP - Lithium Bromide system.	
UNIT III - NON CONVENTIONAL REFRIGERATION SYSTEMS	(9)
Thermoelectric refrigeration system - thermoelectric effects, comparison between thermoelectric and vapour compression refrigeration- vortex tube and pulse tube refrigeration.	
UNIT IV - AIR CONDITIONING SYSTEMS AND EQUIPMENTS	(9)
Air conditioning cycle - classification of air conditioning systems - central system - zoned system - unitary system - unitary central system – VRF/VRV system- selection of system - RSHF - GSHF - applications of air conditioning - air conditioning equipment - package units, central units - noise and noise control.	

UNIT V – LOAD ESTIMATION, APPLICATIONS OF REFRIGERATION AND AIR CONDITIONING	(9)
Cooling and heating load - Thermal resistance value (U) for wall, roof, glass, solar radiation and heat gain - thermal barriers - infiltration - internal heat gains - Design of a cold storage - domestic refrigerator - electrical circuit, maintenance - year round air conditioner - year round absorption air conditioner - air conditioning of theatres - manufacture of ice.	

TEXT BOOKS

1. Rajput.R.K, "A textbook of Refrigeration and Air conditioning", S.K.Kataria and Sons, 3rd ed., Reprint 2015
2. Arora, C.P., "Refrigeration and Air Conditioning", 4th ed., McGraw Hill, New Delhi, 2021

REFERENCES:

1. Ananthanarayanan P.N, "Basic Refrigeration and Air Conditioning",4th ed.,McGraw Hill, New Delhi, 2013
2. Paul Lang V, "Principles of Air conditioning", 3rd ed., CBS Publishers and Distributors Pvt Ltd, New Delhi 2003
3. Khurmi.R.S and Gupta.J.K, "A Textbook of Refrigeration and Air Conditioning", Ist ed., S. Chand Publications, 2011
4. Roy.J.Dossat, "Principles of Refrigeration", 4th ed., Pearson education inc, New Delhi, 2012

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	
2		3											2	
3		3											2	
4		3											2	
5										2				
CO (W.A)	**3**	**3**								**2**			**2**	

22MEX25 THERMAL POWER ENGINEERING

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To study the fuel properties and arrive at proximate and ultimate analysis of fuels. • To study the different types of boilers and compute their performance parameters. • To study the performance parameters of an air compressor. • To study the working principles of various refrigeration systems and perform COP calculations. • To study the psychrometric properties and how they are utilized in arriving at calculations to determine heating loads.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Analyze the properties of different fuels and conduct proximate and ultimate analysis to determine their composition and characteristics.	An	20%
CO2	Explore the various types of boilers and analyze their performance through boiler trials, including calculations and evaluations of efficiency.	An	40%
CO3	Calculate the performance of air compressors and different refrigeration cycles, such as vapor compression, air cycle, and thermoelectric refrigeration systems for the given condition.	Ap	20%
CO4	Use the psychrometric chart to analyze psychrometric processes and support the design of air conditioning systems tailored to different climatic conditions.	An	20%
CO5	Participate in an independent team study and deliver an effective oral presentation on boilers, refrigeration, and air conditioning systems.	U	Internal Assessment

UNIT I : FUELS AND COMBUSTION	**(9)**
Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels – Fuels Analysis – Proximate and Ultimate Analysis - Moisture Determination - Calorific Value -Gross & Net Calorific Values	
UNIT II - BOILERS	**(9)**
Types of boilers and comparison, Mountings and Accessories. Performance calculations, Boiler trial. Next generation boiler design	
UNIT III - AIR COMPRESSORS	**(9)**
Classification of air compressors, working principle, work of compression - with and without clearance, Volumetric efficiency, Isothermal efficiency. Multistage air compressor with Intercooling. Working principle and comparison of Rotary compressors with reciprocating air compressors	
UNIT IV - REFRIGERATION SYSTEMS	**(9)**
Vapour compression refrigeration cycle, Effect of Superheat and Sub-cooling, Performance calculations, Working principle of air cycle, vapour absorption system, and Thermoelectric refrigeration. Advanced refrigeration and Cryogenics	

UNIT V – PSYCHROMETRY AND AIR-CONDITIONING	(9)

Psychrometric properties – Property calculations using Psychrometric chart and expressions. Psychrometric processes – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing Air conditioning systems, concept of RSHF, GSHF and ESHF, Cooling load calculations. Cooling towers – concept and types.

TEXT BOOKS

1. Mahesh. M. Rathore, "Thermal Engineering", 4th Edition, Tata McGraw Hill, 2023.
2. Ballaney. P, "Thermal Engineering", 25th Edition, Khanna Publishers, 2017

REFERENCES:

1. Ananthanarayanan P.N, "Basic Refrigeration and Air-Conditioning", 4th Edition, Tata McGraw Hill, 2013.
2. Arora, "Refrigeration and Air-Conditioning", 4th ed., McGraw Hill, New Delhi, 2021.
3. Mathur M.L and Mehta F.S., "Thermal Science and Engineering", 3rd Edition, Jain Brothers Pvt. Ltd, 2017.
4. Nag P.K, " Basic and Applied Thermodynamics", 4th Edition, Tata McGraw Hill, 2017
5. Soman. K, "Thermal Engineering", 2nd Edition, Prentice Hall of India, 2011

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	
2	3												2	
3		3											2	
4	3												2	
5									2	2				
CO (W.A)	**3**	**3**							**2**	**2**			**2**	

22MEX26 RENEWABLE ENERGY TECHNOLOGIES

	L	T	P	C
	3	0	0	3

PREREQUISITE :

Course Objective:	• To analyze the global energy status and potential of various renewable energy sources. • To understand the different types of bio-resources and their conversion technologies

	Course Outcomes The Student will be able to	Cognitive Level	Weightage of COs in End Semester Examination
CO1	Describe the energy consumption and demands in various sectors like domestic, industrial, commercial, agriculture and transportation in India.	U	20%
CO2	Calculate wind energy potential using wind data, considering factors like the Betz limit and site selection for wind farms.	Ap	20%
CO3	Analyze and Design the biomass gasifiers, biogas plants, biodiesel production plants and ethanol production systems.	An	20%
CO4	Define the methods of hydrogen production and storage and their potential applications in the energy sector	U	20%
CO5	Evaluate applications and design the solar thermal collectors, including flat plate and concentrating collectors, and.	Ev	20%

UNIT I: ENERGY SCENARIO	(9)
Indian energy scenario in various sectors – domestic, industrial, commercial, agriculture, transportation and others – Present conventional energy status – Present renewable energy status- Potential of various renewable energy sources-Global energy status-Per capita energy consumption - Future energy plans	
UNITII:SOLAR ENERGY	(9)
Solar radiation – Measurements of solar radiation and sunshine – Solar spectrum - Solar thermal collectors – Flat plate and concentrating collectors – Solar thermal applications – Solar thermal energy storage – Fundamentals of solar photo voltaic conversion – Solar cells – Solar PV Systems – Solar PV applications.	
UNITIII:WIND ENERGY	(9)
Wind data and energy estimation – Betz limit - Site selection for windfarms – characteristics - Wind resource assessment - Horizontal axis wind turbine – components - Vertical axis wind turbine – Wind turbine generators and its performance – Hybrid systems – Environmental issues - Applications.	
UNITIV:BIO-ENERGY	(9)
Bio resources – Biomass direct combustion – thermochemical conversion - biochemical conversion- mechanical conversion - Biomass gasifier - Types of biomass gasifiers - Cogeneration –- Carbonisation – Pyrolysis - Biogas plants – Digesters –Biodiesel production – Ethanol production - Applications.	
UNITV:OTHER ENERGY SOURCES	(9)
Geothermal energy, magneto hydrodynamic system (MHD), thermionic and thermos- electric generator, micro-hydel systems, hybrid systems and applications; Fuel cells: Classification, reactions and performance; Hydrogen production and storage methods.	
TOTAL=45PERIODS	

TEXT BOOKS:

1. Fundamentals and Applications of Renewable Energy | Indian Edition, by Mehmet Kanoglu, Yunus A. Cengel, John M. Cimbala, cGraw Hill; First edition (10 December 2020), ISBN-10 : 9390385636
2. Renewable Energy Sources and Emerging Technologies, by Kothari, Prentice Hall India Learning Private Limited; 2nd edition (1 January 2011), ISBN-10 : 8120344707

REFERENCES:

1. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 2012.
2. Rai.G.D., "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2014.
3. Sukhatme.S.P., "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2009.
4. Tiwari G.N., "Solar Energy – Fundamentals Design, Modelling and applications", Alpha Science Intl Ltd, 2015.
5. Twidell, J.W. & Weir A., "Renewable Energy Resources", EFNSpon Ltd., UK, 2015.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1		2	2				3						3	
2	3	2	2				3							
3	3	2	2				3						3	
4	3	2	2	3			3							
5	3	2	2			3	3						3	
CO (W.A)	**3**	**2**	**2**	**3**		**3**	**3**						**3**	

22MEX27 - ADVANCED VEHICLE ENGINEERING				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				
Course Objective:	• To introduce the basic concepts of electric vehicle and their characteristics • To introduce different types of motors and the selection of motor for vehicle applications. • To acquaint the student with different sensors and systems used in autonomous and connected vehicles. • To give an overview of networking with sensors and systems. • To introduce the modern methods of diagnosing on-board the vehicle troubles.			

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the concept of electric vehicles and their importance in automotive.	Ap	30%
CO2	Analyze the performance, characteristics and configuration of electric vehicle motors.	Ap	30%
CO3	Analyze the characteristics of networking and Diagnostic Interfaces.	An	20%
CO4	Analyze the on-board diagnostics systems	An	20%
CO5	Seminar presentation in the autonomous vehicle and connected vehicles	U	Internal Assessment

UNIT I - ELECTRIC VEHICLES	**(9)**
EV architectures, advantages and disadvantages, Electrical and mechanical energy storage technologies, battery management. Performance of Electric Vehicles, Electric Power Steering. Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving.	
UNIT II - ELECTRIC VEHICLE MOTORS	**(9)**
Electric Propulsion basics, motor capacity determination, Induction motor, DC motor, Permanent Magnet Motor, Switch Reluctance Motor, Configuration, Characteristics, Performance and control of Drives.	
UNIT III - AUTONOMOUS AND CONNECTED VEHICLES	**(9)**
Vehicle-to-Vehicle Technology, Vehicle to Road and Vehicle to Vehicle Infrastructure, Basic Control System, Surroundings Sensing Systems, Role of Wireless Data Networks, Advanced Driver Assistance Systems, Basics of Radar System, Ultrasonic Sonar Systems, Lidar System, Camera Technology, Basics of Wireless Technology, Receiver System.	
UNIT IV - AUTOMOTIVE NETWORKING	**(9)**
Bus Systems – Classification, Applications in the vehicle, Coupling of networks, networked vehicles, Buses - CAN Bus, LIN Bus, MOST Bus, Bluetooth, Flex Ray, Diagnostic Interfaces.	

UNIT V - ON-BOARD TESTING	(9)
Integration of Sensor Data to On-Board Control Systems (OBD), OBD requirements, certification, enforcement, systems, testing, Introduction to Cyber-physical system.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. John G Hayes and G AbaasGoodarzi, Electric Powertrain -, 1st Edition, John Wiley & Sons Ltd., 2018
2. Hussain T Mouftah, Melike Erol-kantarci and Samesh Sorour, Connected and Autonomous Vehicles in Smart Cities,CRC Press, 1st Edition, 2020.

REFERENCES:

1. Dominique Paret, Multiplexed Networks for Embedded Systems, John Wiley & Sons Ltd., 2007.
2. Hong Cheng, - Autonomous Intelligent Vehicles: Theory, Algorithms & amp; Implementation‖, Springer, 2011
3. Advanced Technology Vehicles Manufacturing (ATVM) Loan Program (Energy Science, Engineering and Technology: Congressional Policies, Practices and Procedures)by Andrew M Wright and Harrison R Scott | 5 September 2012
4. Advanced Vehicle Technology by Heinz Heisler MSc BSc FIMI MIRTE MCIT | 17 July 2002
5. Advanced Motorsport Engineering: Units for Study at Level 3by Andrew Livesey | 1 September 2011

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2												1	
2	2												1	
3		1												
4		1												
5										1				
CO (W.A)	2	1								1			1	

22MEX31-COMPUTATIONAL SOLID MECHANICS

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To study the definition and basics on theory of elasticity • To learn finite element method and procedure for static linear elasticity • To study the Non Linear and History depend problems • To study time dependent and dynamic problems of Small and large strain visco-plasticity • To study Structural Elements & Interfaces and contact using penalty method

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Utilize the theory of elasticity to solve basic problems in structural analysis.	Ap	40%
CO2	Differentiate between non-linear problems and history-dependent problems in the context of structural mechanics.	An	20%
CO3	Evaluate methods for solving structural elements, interfaces, and contact problems.	Ap	20%
CO4	Derive the finite element method for static linear elasticity from first principles.	Ap/C	20%
CO5	Develop teamwork and collaboration skills through group-based on the solid mechanics assignments and peer reviews.	Ap/An	Internal Assessment

UNIT I - BASIC ON THEORY OF ELASTICITY	**(9)**
Definitions- notations and sign conventions for stress and strain, Equations of equilibrium. Strain – displacement relations, Stress – strain relations, Lame's constant –cubical dilation, Compressibility of material, bulk modulus, Shear modulus, Compatibility equations for stresses and strains, Principal stresses and principal strains, Mohr's circle, Saint Venant's principle.	
UNIT II - FINITE ELEMENT METHOD FOR STATIC LINEAR ELASTICITY	**(9)**
Derivation and implementation of a basic 2D FE code with triangular constant strain elements. Generalization of finite element procedures for linear elasticity: interpolation and numerical integration in 1D, 2D and 3D. Deriving finite element equations - constructing variational forms; mixed methods. Accuracy and convergence; the Patch test.	
UNIT III - NON LINEAR AND HISTORY DEPEND PROBLEMS	**(9)**
Small strain hypo-elastic materials - Small strain visco-plasticity - Large strain elasticity -Large strain visco-plasticity	
UNIT IV - TIME DEPENDENT AND DYNAMIC PROBLEMS	**(9)**
First-order systems - the diffusion equation - Explicit time integration – the Newmark method - Implicit time integration - Modal analysis and modal time integration.	

UNIT V – AXISYMMETRIC CONTINUUM AND PLANE TRUSS	(9)
Axisymmetric formulation - Element stiffness matrix and force vector - Body forces and temperature effects - Stress calculations - Boundary conditions – 2D axis symmetric elements.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. L.S.Srinath, Advanced Mechanics Of Solids, 3rd Edition 2008.(0070139881 · 9780070139886).
2. J.N.Reddy, Introduction To Finite Element Method, 4th Edition 2020. (939038527X · 9789390385270).
3. R.D.Cook, Concepts and Applications of Finite Element Analysis, 4th Edition 2001 (978- 0-471-35605-9).
4. S.Timoshenko, Theory of Elasticity, McGraw-Hill Education (India) Pvt Limited, 2010.(9780070701229-0070701229)
5. G. Ramamurty, Applied Finite Element Analysis, I.K. International Publishing House Pvt. Limited,2013. (9789380578453- 9380578458)

REFERENCES:

1. The Mechanics of Solids and Structures - Hierarchical Modeling and the Finite Element Solution (Computational Fluid and Solid Mechanics)by Miguel Luiz Bucalem and KlausJurgen Bathe | 25 February 2013
2. The Finite Element Analysis of Shells - Fundamentals (Computational Fluid and Solid Mechanics)by Dominique Chapelle and Klaus-Jurgen Bathe | 27 January 2013
3. Inelastic Analysis of Solids and Structures (Computational Fluid and Solid Mechanics)by M. Kojic and Klaus-Jurgen Bathe | 22 October 2010
4. High-Resolution Methods for Incompressible and Low-Speed Flows (Computational Fluid and Solid Mechanics)by D. Drikakis and W. Rider | 22 October 2010
5. Discontinuous Finite Elements in Fluid Dynamics and Heat Transfer (Computational Fluid and Solid Mechanics)by Ben Q. Li | 22 October 2010

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2		3											3	
3	3												3	
4	3												3	
5	3								1	1			3	
CO (W.A)	3	3							1	1			3	

22MEX32 - COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To study the fluid flow simulation techniques and its mathematical behaviour • To learn the discretise 1D and 2D systems using finite difference and finite volume techniques • To Formulate diffusion – convection problems using finite volume method • To study the flow field for different types of grids • To learn the need for turbulence models and its types

	Course Outcomes The Student will be able to	**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the fundamentals of CFD, and develop specific governing equations	Ap	30%
CO2	Apply the various discretization methods, solution procedure and the concept of turbulence modeling.	Ap	30%
CO3	Analyze the fluid flow and heat transfer process	An	20%
CO4	Analyze various mathematical schemes under finite volume method for convention diffusion	An	20%
CO5	Design a different environmental friendly model by using the software tools and relate to the course.	Ap	Internal Assessment

UNIT I - COMPUTATIONAL FLUID DYNAMICS	**(9)**
Basics of Computational Fluid Dynamics – Governing equations– Continuity, Momentum and Energy equations – Boundary conditions & Types– Time-averaged equations for Turbulent Flow – Classification and Mathematical behavior of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations, comparison between Analytical, Experimental and Numerical techniques, Techniques of Discretisation and Numerical errors. Post processing techniques.	
UNIT II - FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION	**(9)**
Derivation of finite difference equations– General Methods for first and second order accuracy – Finite volume formulation for steady and transient diffusion 1D and 2D problems – Use of Finite Difference and Finite Volume methods, Accuracy of solution, optimum step-size, Euler, Crank-Nickolson methods, stability of schemes.	
UNIT III - FINITE VOLUME METHOD FOR CONVECTION DIFFUSION	**(9)**
Steady one-dimensional convection and diffusion – Central, upwind differencing schemes, properties of discretization schemes, Hybrid, Power-law, Quick Schemes, Computation of Boundary layer flow, von Neumann stability analysis.	

UNIT IV - FLOW FIELD ANALYSIS	(9)
Stream function and vorticity, Representation of the pressure gradient term, Staggered grid – Momentum equations, Pressure and Velocity corrections – Pressure Correction equation, Simple algorithm and its variants – PISO Algorithms, Computation of internal and external thermal boundary layer.	
UNIT V - TURBULENCE MODELLING	**(9)**
Turbulence model requirement and types, mixing length model, Two equation (k-Є) models – High and low Reynolds number models, LES, DNS, Mesh Generation and refinement Techniques-software tools, Stability of solver, Courant Fredrick Levy number, relaxation factor, and grid independence test.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Versteeg, H.K., and Malalasekera, W.,"An Introduction to Computational Fluid Dynamics": The finite volume Method, Pearson Education, 2014 .
2. Ghoshdastidar, P.S., "Computational Fluid Dynamics and Heat Transfer", Cengage Learning, 2017.

REFERENCES:

1. John. F. Wendt, "Computational Fluid Dynamics – An Introduction", Springer, 2013.
2. K. Muralidhar & T.Sundararajan, Computational Fluid Flow and Heat Transfer, Narora Publishing House, 1994.
3. Suhas V, Patankar, "Numerical Heat transfer and Fluid flow", Taylor & Francis, 2009.
4. Uriel Frisch, Turbulence, Cambridge University Press, 1999.
5. Yogesh Jaluria & Kenneth E. Torrance, "Computational Heat Transfer", CRC press, 2002.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2													
2	2													
3		2			1								1	1
4		2											1	1
5							1							
CO (W.A)	2	2			1		1						1	1

22MEX33 THEORY ON COMPUTATION AND VISUALIZATION

	L	T	P	C
	3	0	0	3

PREREQUISITE : Nil

Course Objective:

- To study the concepts and techniques of discrete mathematics for theoretical computer science.
- To learn different formal languages and their relationship.
- To classify and construct grammars for different languages and vice-versa
- To study visualization, graphical and quantitative information
- To learn Visualization design and data Ink

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the concepts and techniques of discrete mathematics for theoretical computer science	Ap	30%
CO2	Analyze the different formal languages and their relationship	An	20%
CO3	Classify and construct grammars for different languages and vice-versa	Ap	30%
CO4	Evaluate the visualization, graphical and quantitative information	E	20%
CO5	Create visualization design and data ink	U	Internal Assessment

UNIT I- REVIEW OF MATHEMATICAL THEORY	**(9)**
Sets, functions, logical statements, proofs, relations, languages, principal of mathematical induction, strong principle, recursive definitions, structural induction.	
UNIT II - REGULAR LANGUAGES AND FINITE AUTOMATA	**(9)**
Regular expressions, regular languages, application of finite automata, automata with output –mealy machine, finite automata, definitions, union- intersection and complement of regular languages, non deterministic finite automata, conversion from NFA to FA, - non deterministic finite automata, conversion of NFA- to NFA, kleene's theorem, minimization of finite automata, regular and non regular languages – pumping lemma.	
UNIT III - CONTEXT FREE GRAMMAR (CFG) AND PUSHDOWN AUTOMATA	**(9)**
Definitions and examples, unions concatenations and kleene's of context free language, regular grammar for regular language, derivations and ambiguity , unambiguous CFG and algebraic expressions, bacosnaur form (BNF), normal form – CNF. Definitions, deterministic PDA, equivalence of CFG and PDA conversion, pumping lemma for CFL, intersections and complements of CFL, non-CFL.	
UNIT IV - VALUE OF VISUALIZATION	**(9)**
Information visualization, in readings in information visualization, graphical excellence, graphical integrity, sources of graphical integrity in the visual display of quantitative information.	
UNIT V – VISUALIZATION DESIGN	**(9)**
The power of representation, data-ink and graphical redesign, data-ink maximization and graphical design, data density and small multiples.	

TEXT BOOKS:
1. Introduction to the theory of computation by michael sipser. 2. Automata theory, languages, and computation by john hopcroft, rajeev motowani, and jeffrey ullman.
REFERENCES:
1. Introduction to languages and the theory of computation, 4th by john martin, tata mc graw hill 2. An introduction to automata theory and formal languages by adesh k. pandey, publisher: s.k. kataria&sons 3. Introduction to computer theory by deniel i. cohen , joh wiley & sons, inc 4. Computation: finite and infinite by marvin l. minsky prentice-hall.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												1	
2		3											1	
3			2										1	
4				2									1	
5												2		
CO (W.A)	3	3	2	2								2	1	

22MEX34-COMPUTATIONAL BIO-MECHANICS

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To Introduction of principles and concepts of bio-mechanics. • Focuses on the studies of tissues and structure of musculoskeletal system. • To study the mechanics of joints and human motion. • To explain the computational approaches in biomechanics • To learn the quantification of forces and motion.

	Course Outcomes The Student will be able to	**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Utilize the principles of mechanics to analyze various biomechanical systems	Ap	40%
CO2	Investigate the tissues and structures of the musculoskeletal system in detail.	An	20%
CO3	Assess the effectiveness of different computational mathematical models applied in biomechanics.	Ap	30%
CO4	Formulate new techniques for analyzing and understanding human motion.	Ap/C	10%
CO5	Develop teamwork and collaboration skills through group-based biomechanics assignments and peer reviews.	Ap/An	Internal Assessment

UNIT I - INTRODUCTION TO BIOMECHANICS	**(9)**
Perspective of biomechanics, Terminologies, Kinematic and kinetic concepts for analyzing human motion, Kinetic concepts for analyzing human motion, Linear kinetics of human movement, Equilibrium, Angular kinetics of human Movement, Mechanical properties of soft tissues, bones, and muscles	
UNIT II - BIOMECHANICS OF TISSUES AND STRUCTURES OF THE MUSCULOSKELETAL SYSTEM	**(9)**
Biomechanics of Bone, Biomechanics of Articular Cartilage, Tendons and Ligaments, Peripheral Nerves and Spinal Nerve Roots, Skeletal Muscle	
UNIT III - BIOMECHANICS OF JOINTS AND HUMAN MOTION	**(9)**
Knee, Hip, Foot and Ankle, Lumbar Spine, Cervical Spine, Shoulder, Elbow Wrist, and Hand, Linear kinematic and kinetic aspects of human movement, angular kinematic and kinetic aspects of human movement, equilibrium and human moment.	
UNIT IV - COMPUTATIONAL APPROACHES IN BIOMECHANICS	**(9)**
Finite Element Analysis in Biomechanics, Computational modelling of Vancouver Periprosthetic Fracture in Femur, Scaffolds, artificial hip and knee joints, Aortic Valve.	
UNIT V – GAIT ANALYSIS	**(9)**
Exoskeleton design, Ergonomics, Sports mechanics, Performance Analysis, Biomechanical analysis, 3D printing.	
TOTAL(L:45) = 45 PERIODS	

TEXT BOOKS:

1. Susan J Hall, —Basic Biomechanics, 6th Edition, The McGraw-Hill Companies Inc., 2011
2. Jay D Humphrey and Sherry L Delange, —An Introduction to Biomechanics: Solids and Fluids, Analysis and Design, 1st edition, Springer-Verlag, 2010

REFERENCES:

1. Margareta Nordin and Victor H Frankel, —Basic Biomechanics of the Musculoskeletal System, 3rd Edition, Lippincott Williams and Wilkins, 2001.
2. Ozkaya, Nihat, Nordin, and Margareta, —Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, 2nd Edition, Springer, 2009.
3. Pritam Pain, Sreerup Banerjee, Goutam Kumar Bose , Advances in Computational Approaches in Biomechanics, 2022
4. Kinetics and Dynamics: From Nano- to Bio-Scale: 12 (Challenges and Advances in Computational Chemistry and Physics)by Piotr Paneth and Agnieszka Dybala-Defratyka | 12 August 2010
5. Computational Approaches to Biochemical Reactivity: 19 (Understanding Chemical Reactivity) by GáborNáray-Szabó and AriehWarshel | 31 March 2002

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2		3											3	
3	3												3	
4	3												3	
5	3								1	1			3	
CO (W.A)	3	3							1	1			3	

22MEX35 - DESIGN OF PRESSURE VESSELS

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:

- To introduce the Mathematical knowledge to design pressure vessels and piping
- To learn the ability to carry of stress analysis in pressure vessels and piping
- To study the design of vessels and theory of reinforcement.
- To study buckling and fracture analysis in vessels.
- To learn piping layout and flow diagram.

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the various method to determine stress in pressure vessels.	Ap	20%
CO2	Apply the stress concept in pressure vessels.	Ap	20%
CO3	Analysis of stresses in pressure, buckling and fracture analysis in vessels.	An	30%
CO4	Design and analysis of vessels, piping layout and piping.	An	30%
CO5	Engage independent study as a member of team and make effective oral presentation on the application of PLM	U	Internal Assessment

UNIT I - INTRODUCTION	**(9)**
Methods for determining stresses – Terminology and Ligament Efficiency – Applications	
UNIT II - STRESSES IN PRESSURE VESSELS	**(9)**
Introduction – Stresses in a circular ring, cylinder –Dilation of pressure vessels, Membrane stress Analysis of Vessel – Cylindrical, spherical and, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.	
UNIT III - DESIGN OF VESSELS	**(9)**
Design of Tall cylindrical self-supporting process columns – Supports for short vertical vessels – Stress concentration at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – Pressure Vessel Design	
UNIT IV - BUCKLING AND FRACTURE ANALYSIS IN VESSELS	**(9)**
Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.	
UNIT V – PIPING	**(9)**
Introduction – Flow diagram – piping layout and piping stress Analysis.	
TOTAL : 45 PERIODS	

TEXT BOOKS:

1. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publishers and Distributors,1987.
2. Theory And Design Of Pressure Vessels (Pb 2001) by HARVEY J.F. | 1 January 2001

REFERENCES:

1. Henry H. Bedner, "Pressure Vessels, Design Hand Book", CBS publishers and Distributors,1987.
2. Stanley, M. Wales, "Chemical process equipment, selection and Design". Buterworths series in Chemical Engineering, 1988.
3. William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Pre ASME Pressure Vessels and Piping Conference, 1997.
4. Sam Kannapan, "Introduction to Pipe Stress Analysis". John Wiley and Sons, 1985.
5. Theory and design of Pressure Vessels (Pb 2001)by HARVEY J.F. | 1 January 2001

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1													1	
2	3												1	
3		3											1	
4			1										1	
5										1			1	
CO (W.A)	3	3	1							1			1	

22MEX37 FAILURE ANALYSIS AND NDT TECHNIQUES

L	T	P	C
3	0	0	3

PREREQUISITE :

Course Objective:	• To gain knowledge on the need, scope, and methodologies of failure analysis • To learn the principles and applications of visual and penetrant testing • To Understand the principles, techniques, and advanced methods of magnetic particle testing • To learn the principles and techniques of radiographic inspection using X-ray and gamma radiography • To teach various safety standards and precautions in nondestructive testing methods.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the principles, methods, and applications of various non-destructive testing techniques	Ap	40%
CO2	Apply the failure analysis strategies in engineering.	Ap	20%
CO3	Analyze non-destructive testing methods for suitable application and interpret failure modes	An	20%
CO4	Analyze failure analysis, including FMEA and RCA, to investigate and prevent engineering failures	An	20%
CO5	Implement safety protocols in non-destructive testing methods.	U/Ap	Internal Assessment

UNIT I - FAILURE ANALYSIS	**(9)**
Introduction and need and scope of failure analysis. Engineering Disasters and understanding failure analysis. Fundamental sources of failures.Failuremodes and effects analysis (FMEA) in industry.Role of root cause analysis (RCA) in failure investigation.failure prevention strategies: Design optimization, material selection, quality control	
UNIT II - VISUAL INSPECTION AND PENETRANT TESTING	**(9)**
Non destructive testing - advantages- comparison between destructive and non destructive testing -visual inspection - basic terms, equipments used - machine vision Health and safety considerations in NDT: Personal protective equipment (PPE), exposure limits-Principle of penetrant testing - test stations - accessories - applications - types of penetrants - characteristics of good penetrants - developer and its types - quality and process control - health and safety precautions in Liquid penetrant Inspection.	
UNIT III : MAGNETIC PARTICLE TESTING	**(9)**
Principle of Magnetic particle testing - scope - basic terms associated with magnetic materials, classification of magnetic materials - magnetic field orientation - direct magnetization, indirect magnetization - DC and AC magnetization – skineffect - equipments - lights - magnetic field indicator - Advanced magnetic particle testing methods: Multi-directional magnetization, rotational magnetization, automated magnetic particle inspection systems: Robotics, Computer vision Integration, Emerging trends in magnetic particle inspection: Nano-particle enhanced testing.	
UNIT IV: RADIOGRAPHIC INSPECTION	**(9)**
Types of radiations - X-Ray radiography principle - X ray tube generator - gamma radiation sources - advantages of gamma rays over X ray radiography - X-Ray film and accessories - film interpretation - digital radiography - precautions against radiation hazards and health - Real-time radiography and tomography techniques. Radiographic image interpretation: Defect detection and sizing	

UNIT V : ULTRASONIC AND EDDY CURRENT TESTING	(9)
Principle of ultrasonic testing - equipments used in ultrasonic testing -Ultrasonic inspection techniques – transmission method, pulse echo method, immersion technique, angle beam technique- applications – cathode ray oscilloscope – Ultrasonic testing for composite materials and additive manufacturing parts- Introduction to Phased Array Ultrasonic Testing (PAUT).Eddy current testing - working principle - basic terms -factors affecting eddycurrents - eddy current flow characteristics - applications	
TOTAL=45PERIODS	

TEXTBOOKS:

1. Osama Lari, Rajeev Kumar, "Basics of Non-Destructive testing", 1st ed., S.K.Kataria and Sons, 2013
2. Baldev Raj, T.Jayakumar, M.Thavasimuthu Practical Non-Destructive Testing, Narosa Publishing House, 2014.

REFERENCES:

1. ASM International,"ASM Handbook: Nondestructive Evaluation and Quality Control - Volume 17", 9th Revised edition, 1989
2. Charles, J. Hellier, Handbook of Non destructive evaluation, McGraw Hill, New York 2001.
3. Ravi Prakash, "Non-Destructive Testing Techniques", First Revised edition, New Age International (P) Limited, 2010
4. Prasad.J and Nair.C.G.K, "Non-Destructive Test and Evaluation of Materials", 2nd ed., Tata McGraw-Hill Publishing company Limited, 2011
5. Yoshida Kenichi and Laodeno Rem N, "Non-Destructive Testing Technique", LAP Lambert Academic Publishing, 2013

Mapping of COs with POs / PSOs

Cos	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	2
2	3												3	2
3		2											2	
4		2												
5						2		2				2		
CO (W.A)	3	2				2		2				2	3	2

22MEX38 MACHINE LEARNING FOR INTELLIGENT SYSTEMS

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To introduce basic machine learning techniques such as regression, classification • To learn about introduction of clustering, types and segmentation methods • To learn about fuzzy logic, fuzzification and defuzzification • To learn about basics of neural networks and neuro fuzzy networks • To learn about recurrent neural networks and reinforcement learning

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply basic machine learning techniques such as regression, classification	Ap	20%
CO2	Develop and analyze clustering and segmentation methods	An	20%
CO3	Applying a fuzzy logic system with fuzzification and defuzzification.	Ap	40%
CO4	Apply the concepts of neural networks and neuro fuzzy networks	Ap	20%
CO5	Improve knowledge on reinforcement learning	U	Internal Assessment

UNIT I- INTRODUCTION TO MACHINE LEARNING	(9)
Philosophy of learning in computers, overview of different forms of learning, classifications vs. regression, evaluation metrics and loss functions in classification, evaluation metrics and loss functions in regression, applications of ai in robotics.	
UNIT II - CLUSTERING AND SEGMENTATION METHODS	(9)
Introduction to clustering, types of clustering, agglomerative clustering, K-means clustering, mean shift clustering, K-means clustering application study, Introduction to recognition, K-nearest neighbor algorithm, KNN application case study, principal component analysis (PCA), PCA application case study in feature selection for robot guidance.	
UNIT III - FUZZY LOGIC	(9)
Introduction to fuzzy sets, classical and fuzzy sets, overview of classical sets, membership function, fuzzy rule generation, fuzzy rule generation, operations on fuzzy sets, numerical examples, fuzzy arithmetic, numerical examples, fuzzy logic, fuzzification, fuzzy sets, defuzzification, application case study of fuzzy logic for robotics application.	
UNIT IV - NEURAL NETWORKS	(9)
Mathematical models of neurons, ANN architecture, learning rules, multi-layer perceptrons, back propagation, introduction of neuro-fuzzy systems, architecture of neuro fuzzy networks, application case study of neural networks in robotics.	

UNIT V – RNN AND REINFORCEMENT LEARNING	(9)
Unfolding computational graphs, recurrent neural networks, application case study of recurrent networks in robotics, reinforcement learning, examples for reinforcement learning, markov decision process, major components of RL, Q-learning. application case study of reinforcement learning in robotics.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Micheal negnevitsky, artificial intelligence: a guide to intelligent systems, 3rd edition, addision wesley, england, 2011.
2. The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman (freely available online)
3. Pattern Recognition and Machine Learning, by Christopher Bishop.

REFERENCES:

1. Bruno siciliano, oussama khatib, "handbook of robotics", 2016 2nd edition, springer
2. Simon haykin, "neural networks and learning machines: a comprehensive foundation", third edition, pearson, delhi 2016.
3. Timothy j ross, "fuzzy logic with engineering applications", 4th edition, chichester, 2011, sussex wiley.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												1	
2		3												
3	3													
4					3								1	
5												2		
CO (W.A)	3	3			3							2	1	

22MEX41 – DIGITAL MANUFACTURING AND IoT				
	L	T	P	C
	3	0	0	3
PREREQUISITE :				

Course Objective:	• To study the various aspects of digital manufacturing. • To inculcate the importance of DM in Product Lifecycle Management and Supply chain Management. • To formulate of smart manufacturing systems in the digital work environment. • To interpret IoT to support the digital manufacturing. • To elaborate the significance of digital twin.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply and Impart knowledge to use various elements in the digital manufacturing.	Ap	20%
CO2	Differentiate the concepts involved in digital product development life cycle process and supply chain management in digital environment.	An	20%
CO3	Develop the proper procedure of validating practical work through digital validation in Factories.	An	40%
CO4	Explore and Implement the concepts of IoT and its role in digital manufacturing.	Ap	20%
CO5	Evaluate and optimize various practical manufacturing process through digital twin.	Ap	Internal Assessment

UNIT I - INTRODUCTION TO DIGITAL MANUFACTURING AND IoT	(9)
Introduction – Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing. IoT Sensors – Temperature, Pressure, Gyroscope, Motion detection and proximity.	
UNIT II - DIGITAL LIFE CYCLE & SUPPLY CHAIN MANAGEMENT	(9)
Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM, New Product Development (NPD) process, stages, test marketing & product launch	
UNIT III - SMART FACTORY	(9)
Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cyber security – Advanced Simulation Tool – Solid works, MATLAB, SIMUL8, Logisim.	

UNIT IV - INDUSTRY 4.0	(9)
Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems (CPS) –Machine to Machine communication – Case Studies. IoT Applications in Agriculture, Healthcare, Transportation, Hospitality, Smart Grid and Energy saving.	
UNIT V - STUDY OF DIGITAL TWIN	(9)
Basic Concepts – Features and Implementation – Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", A press, 2016.

REFERENCES:

1. Lihui Wang and Andrew YehChing Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009.
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019.
3. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017
4. Ronald R. Yager and Jordan Pascual Espada, "New Advances in the Internet of Things", Springer., Switzerland, 2018.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	
2					3							3		
3			3			3								
4														
5														
CO (W.A)	3		3		3	3						3	3	

22MEX42 ADDITIVE MANUFACTURING

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:	• To introduce the fundamental concepts of Additive Manufacturing (AM) technology and to identify the business opportunities and future directions in AM • To understand the role of CAD modeling in AM and the post-processing techniques.

	Course Outcomes The Student will be able to	Cognitive Level	Weightage of COs in End Semester Examination
CO1	Evaluate the benefits and diverse applications of AM in the areas of building, bio, food, and electronics.	Ev	20%
CO2	Describe the processes, materials, advantages, and limitations of stereolithography (SLA), digital light processing (DLP), and continuous liquid interface production (CLIP).	U	20%
CO3	Generate accurate STL files and address errors through CAD software for AM.	Ap	20%
CO4	Identify the current and potential business opportunities in the AM industry and predict future trends.	An	20%
CO5	Analyze the suitable process for different AM techniques for specific applications.	An	20%

UNITI: FUNDAMENTALS OFADDITIVE MANUFACTURING AND BUSINESS OPPORTUNITIES	**(9)**
Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping- Rapid Tooling-Rapid Manufacturing - Additive Manufacturing. AM Process Chain- ASTM/ISO 52900 Classification - Benefits. Applications: Building Printing - Bio Printing - Food Printing- Electronics Printing. Business Opportunities and Future Directions –	
UNITII:DESIGN FOR ADDITIVE MANUFACTURING	**(9)**
Concepts and Objectives - AM Unique Capabilities - Part Consolidation – Topology Optimization- Generative design - Lattice Structures - Multi-Material Parts and Graded Materials - AMF Design for Part Quality Improvement: Part Orientation - Support Structure - Slicing - Tool Path Generation – Design rules for Extrusion based AM.	
UNITIII:VAT POLYMERIZATION AND DIRECTED ENERGY DEPOSITION	**(9)**
Photo polymerization: Stereolithography Apparatus (SLA)- Materials -Process – top down and bottom up approach - Advantages - Limitations - Applications. Digital Light Processing (DLP) - Process - Advantages - Applications. Continuous Liquid Interface Production (CLIP) Technology.Directed Energy Deposition: Laser Engineered Net Shaping (LENS)- Process - Material Delivery - Materials -Benefits -Applications.	
UNITIV:POWDER BED FUSION AND MATERIAL EXTRUSION	**(9)**
Powder Bed Fusion: Selective Laser Sintering (SLS): Process - Powder Fusion Mechanism - Materials and Application. Selective Laser Melting (SLM), Electron Beam Melting (EBM): Materials - Process - Advantages and Applications. Material Extrusion: Fused Deposition Modeling (FDM)- Process-Materials -Applications and Limitations.	

UNIT V:CAD MODELLING AND POST-PROCESSING	(9)
CAD Software for AM: AM file format, STL file generation, accuracy of STL files, errors and repairs in STL files, direct and adaptive slicing; Design for additive manufacturing - design for minimum material usage. Post-processing: Support material removal, surface texture improvements, aesthetic improvements, property enhancement using thermal and non-thermal techniques.	
TOTAL= 45 PERIODS	

TEXT BOOKS:

1. Ian Gibson, David Rosen, Brent Stucker, MahyarKhorasani "Additive manufacturing technologies". 3rd edition Springer Cham, Switzerland. (2021). ISBN: 978-3-030-56126-0
2. Andreas Gebhardt and Jan-Steffen Hötter "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications, United States, 2015, ISBN: 978-1-56990-582-1.

REFERENCES:

1. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.
2. Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies, and Applications", Woodhead Publishing., United Kingdom, 2016, ISBN: 9780081004333.
3. Amit Bandyopadhyay and Susmita Bose, "Additive Manufacturing", 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590.
4. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer., United States, 2006, ISBN: 978-1-4614-9842-1.
5. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press., United States, 2011, ISBN: 9780849334092.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												3	3
2	3	3											2	3
3			3											3
4											3			3
5							3					3	3	3
CO (W.A)	3	3	3				3				3	3	2.6	3

22MEX43 – GREEN MANUFACTURING DESIGN & PRACTICES

L	T	P	C
3	0	0	3

PREREQUISITE :

Course Objective:

- To familiarize the concept of environmental design and industrial ecology.
- To impart knowledge of air pollution and its effects on the environment.
- To emphasize knowledge about noise pollution and its control.
- To enlighten the students with knowledge about water pollution and its effects on the environment.
- To emphasize the need of green co-rating and its benefits.

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply knowledge on the environmental design and selection of eco-friendly materials.	Ap	20%
CO2	Analyze the processes plan minimization for preventing air pollution.	An	20%
CO3	Recognize the methods to prevent noise pollution and its hazards	Ap	40%
CO4	Design and develop the impact of water demand and pollutants of water.	Ap	20%
CO5	Evaluate green co-rating and its benefits.	An/ Cr	Internal Assessment

UNIT I - DESIGN FOR ENVIRONMENT AND LIFE CYCLE ASSESSMENT (9)

Environmental effects of design - Selection of natural friendly material - Eco design - Environmental damage Material flow and cycles – Material recycling – Emission less manufacturing- Industrial Ecology – Pollution prevention – Reduction of toxic emission – design for recycle.

UNIT II - AIR POLLUTION SAMPLING AND MEASUREMENT (9)

Primary and Secondary Pollutants, Automobile Pollutants, Industrial Pollution, Ambient air quality Standards, Metrological aspects of air Pollution, Temperature lapse Rates and Stability-wind velocity and turbulence-Pump behavior dispersion of air Pollutants-solution to the atmosphere dispersion equation-the Gaussian Plume Model, Air pollution sampling-collection of gaseous air pollutants-collection of particulate pollutants-stock sampling, analysis of air pollutants - sulfur dioxide-nitrogen dioxide, carbon monoxide, oxidants and ozone.

UNIT III - NOISE POLLUTION AND CONTROL (9)

Frequency and Sound Levels, Units of Noise based power radio, contours of Loudness. Effect of human, Environment and properties, Natural and Anthrogenic Noise Sources, Measuring Instruments for frequency and Noise levels, Masking of sound, Types, Kinetics, Selection of different reactors used for waste treatment, Treatment of noise at source, Path and Reception, Sources of noise, Effects of noise-Occupational Health hazards, thermal Comforts, Heat Island Effects, Radiation Effects.

UNIT IV - WATER DEMAND AND WATER QUALITY (9)

Factors affecting consumption, Variation, Contaminants in water, Nitrates, Fluorides, Detergents, taste and odour, Radio activity in water, Criteria, for different impurities in water for portable and non-portable use, Point and non-point Source of pollution, Major pollutants of Water, Water Quality Requirement for different uses, Global water crisis issues.

UNIT V - GREEN CO-RATING	(9)
Ecological Footprint - Need For Green Co-Rating – Green Co-Rating System – Intent – System Approach – Weightage - Assessment Process – Types of Rating – Green Co-Benefits – Case Studies of Green Co-Rating	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
2. Rao M.N. and Dutta A.K. "Wastewater treatment", Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2006

REFERENCES:

1. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
2. Frances Cairncross– Costing the Earth: The Challenge for Governments, the Opportunities for Business – Harvard Business School Press – 1993.
3. World Commission on Environment and Development (WCED), Our Common Future, Oxford University Press 2005.
4. Rao M.N. and Dutta A.K. "Wastewater treatment", Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2006
5. Rao CS Environmental Pollution Control Engineering-, Wiley Eastern Ltd., New Delhi, 2006.
6. Lewis H Bell and Douglas H Bell, Industrial noise control, Fundamentals and applications, Marcel Decker, 1994.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1			3				3						2	
2	3													
3												3		
4		3												
5														
CO (W.A)	3	3	3				3					3	2	

22MEX44 - CASTING AND WELDING PROCESSES

L	T	P	C
3	0	0	3

PREREQUISITE : NIL

Course Objective:

- To study the ferrous casting metallurgy and its applications
- To study the nonferrous casting metallurgy and its applications
- To study the ferrous welding metallurgy and its applications
- To study the welding metallurgy of alloy steels and nonferrous metals and its applications
- To Identifying the causes and remedies of various welding defects; applying welding standards and codes.

	Course Outcomes The Student will be able to	**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply comprehensive knowledge of ferrous and non-ferrous alloys, to effectively contribute to the field of metallurgical engineering.	Ap	20%
CO2	Analyze the advanced principles of solidification, microstructural analysis, alloy composition, and welding techniques.	An	20%
CO3	Design and develop advanced materials and processes in metallurgical engineering by applied comprehensive knowledge of ferrous and non-ferrous alloy.	Ap	20%
CO4	Apply ethical principles and professional responsibility in the practice and management of metallurgical engineering processes.	Ap	20%
CO5	Continuously update knowledge and skills in metallurgical engineering, including solidification processes, alloy compositions, welding techniques, and defect analysis	Ap	20%

UNIT I- FERROUS CAST ALLOYS **(9)**

Solidification of pure metals and alloys and eutectics -Nucleation - Growth Process, Critical nucleus size- Super cooling- Niyama Criterion -G/R ratio- Cell- Dendritic - Random dendritic structure-Segregation and Coring- Eutectics-Compositions and alloys in Cast Irons, FG-CGI- SG structures, Metallic Glass- Mold dilation, Mold metal reactions- Structure and Section sensitivity Cast irons- family & microstructures-Alloying effects- Malleable Iron, ADI, Charge calculations- Effect of normal elements and alloying elements in steels- Compositional aspects and properties of alloy steels- melting procedure and composition control for carbon steels- low alloy steels - stainless steels- composition control- slag-metal reactions-desulphurization-dephosphorization, specifications for carbon steels- low alloy steels and stainless steels .

UNIT II - NON-FERROUS CAST ALLOYS **(9)**

Copper- Aluminium- Magnesium- zinc - Nickel base alloys- melting practices - Al alloys, Mg alloys, Nickel alloys, Zinc alloys and copper alloys-modification and grain refinement of Al alloys- problems in composition control- degassing techniques -Heat Treatment of Aluminium alloys – Basics of Solution and Precipitation process. - Applications of Aluminium Alloy castings in various fields. Residual Stresses- defects in castings.

UNIT III - PHYSICAL METALLURGY OF WELDING	(9)
Welding of ferrous materials: Formation of different microstructural zones in welded plain-carbon steels. Welding of C-Mn and low-alloy steels, phase transformations in weld and heat - affected zones, cold cracking, role of hydrogen and carbon equivalent, formation of acicular ferrite and effect on weld metal toughness.	
UNIT IV - WELDING OF ALLOY STEELS AND NON-FERROUS METALS	**(9)**
Welding of stainless steels, types of stainless steels, overview of joining ferritic and martensitic types, welding of austenitic stainless steels, Sensitisation, hot cracking, sigma phase and chromium carbide formation, ways of overcoming these difficulties, welding of cast iron. Welding of non-ferrous materials: Joining of aluminium, copper, nickel and titanium alloys, problems encountered and solutions.	
UNIT V – DEFECTS, WELDABILITY AND STANDARDS	**(9)**
Defects in welded joints: Defects such as arc strike, porosity, undercut, slag entrapment and hot cracking, causes and remedies in each case. Joining of dissimilar materials, weldability and testing of weldments. Introduction to International Standards and Codes.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Heine R W, Loper C R and Rosenthal P C, "Principles of Metal Castings", Tata McGraw Hill, 2017
2. A.K.Chakrabarthi, 'Casting Technology and Cast Alloys, Prentice Hall, 2005.

REFERENCES:

1. Baldev Raj, Shankar V, Bhaduri A K, "Welding Technology for Engineers", Narosa Publications, 2009.
2. Beeley P, "Foundry Technology" Butterworth-Heinemann, 2001.
3. R.S.Parmar, 'Welding Engineering and Technology', Khanna Publishers, 2010
4. John Campbell, "Casting", Butterworth-Heinemann, 2003.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												2	1
2		3											2	1
3			3										2	1
4								3					2	1
5												3	2	1
CO (W.A)	3	3	3					3				3	2	1

22MEX45– ENVIRONMENT SUSTANABILITY AND IMPACT ASSESSMENT

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To understand the concepts of Environmental Sustainability & Impact Assessment • To familiarize the students in environmental decision making procedure. • To identify, predict and evaluate the economic, environmental, and social impact of development activities • To provide information on the environmental consequences for decision making • To promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

	Course Outcomes The Student will be able to	**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply the concepts of Environment Sustainability and trained to make decision related to Environment.	Ap	20%
CO2	Implement lifelong learning skills to make a decision that has an effect on our environment	An	20%
CO3	Evaluate the basics of environmental policy, planning and various legislation	An	40%
CO4	Design and optimize the Life cycle assessment of Environmental sustainability.	Ap	20%
CO5	Analyze the suitable sustainable urban economic development.	An/Ap	Internal Assessment

UNIT I - ENVIRONMENTAL IMPACT ASSESMENT (9)

Environmental impact assessment objectives – rationale and historical development of EIA - Conceptual frameworks for EIA Legislative development – European community directive – Hungarian directive. Case studies on air quality, water quality, noise pollution and ecosystem upset.

UNIT II - ENVIRONMENTAL DECISION MAKING (9)

Strategic environmental assessment and sustainability appraisal – Mitigation, monitoring and management of environmental impacts- Socio economic impact assessment. Case Studies on use of transport, making consumer decisions, planning new or improved developments and managing natural resources.

UNIT III - ENVIRONMENTAL POLICY, PLANNING AND LEGISLATION (9)

Regional spatial planning and policy – Cumulative effects assessment – Planning for climate change, uncertainty and risk. Case studies on Strategy for the Chemical BREFs series review cycle, Carbon Monoxide Emissions from Medium Combustion Plants and Assessment of permitting stringency in industrial installations.

UNIT IV - LIFE CYCLE ASSESSMENT	(9)
Life cycle assessment; Triple bottom line approach; Industrial Ecology. Ecological foot printing, Design for Environment, Future role of LCA, Product stewardship, design, durability and justifiability, measurement techniques and reporting. Life cycle inventory analysis (LCI). Social Life Cycle Assessment (SLCA).	
UNIT V - SUSTAINABLE URBAN ECONOMIC DEVELOPMENT	**(9)**
Spatial economics – Knowledge economy and urban regions. Case studies on market forces in the development of cities, land use within cities, urban transportation, urban problems and public policy, housing and public policy, and local government expenditures and taxes.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. The Application of Science in Environmental Impact Assessment, by Aaron J. MacKinnon, Peter N. Duinker , Tony R. Walker , Routledge; 1st edition (14 May 2019), ISBN-10 : 0367340194
2. Routledge Handbook of Environmental Impact Assessment, by Kevin Hanna, Routledge; 1st edition (11 April 2022), ISBN-10 : 0367244470

REFERENCES:

1. Clive George, C. Collin, H. Kirkpolarice – Impact Assessment and sustainable development – Edward Elgar Publishing, 2007
2. Robort B Gibsan, Sustainability Assessment, Earth Scan publishers, 2005
3. Simon Dresner, The principle of sustainability – Earth Scan publishers, 2008
4. Canter, R.L., "Environmental Impact Assessment", McGraw Hill Inc., New Delhi, 1996.
5. Shukla, S.K. And Srivastava, P.R., "Concepts In Environmental Impact Analysis", Common Wealth Publishers, New Delhi, 1992.
6. John G. Rau And David C Hooten "Environmental Impact Analysis Handbook", McGraw Hill Book Company, 1990.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3													
2		2											2	
3			3											
4												3		
5							3							
CO (W.A)	3	2	3				3					3	2	

22MEX46-SURFACE ENGINEERING

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:

- To study the fundamentals of surface features and different types of friction associated with metals and non-metals
- To study the different types of wear mechanism and its standard measurement.
- To study the different types of corrosion and its preventive measures
- To study the different types of surface properties and surface modification techniques
- To study the various types of materials used in the friction and wear applications

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Apply the concepts and terminology of surface engineering	Ap	30%
CO2	Apply the surface engineering methods to the mechanical component	Ap	30%
CO3	Analyze the surface of the mechanical component	Ap	20%
CO4	Design surface treatments for industrial applications.	An	20%
CO5	Engage independent study as a member of team and make effective oral presentation on the surface Engineering techniques	U	Internal Assessment

UNIT I - SURFACES AND FRICTION	**(9)**
Basics of surfaces features – Roughness parameters – surface measurement - Cause of friction- Laws of friction – Static friction – Rolling Friction – Stick-slip Phenomenon - Friction properties of metal and nonmetals – Friction in extreme conditions – Thermal considerations in sliding contact.	
UNIT II - WEAR	**(9)**
Laws of Wear - Types of Wear mechanism – wear debris analysis - Theoretical wear models - Wear of metals and nonmetals – International standards in friction and wear measurements	
UNIT III - CORROSION	**(9)**
Introduction – Types of corrosion – Factors influencing corrosion – Testing of corrosion – In-service monitoring, Simulated service, Laboratory testing – Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors	
UNIT IV - SURFACE TREATMENTS	**(9)**
Surface properties – Hydrophobic – Super hydrophobic – Hydrophilic - surface metallurgy –Surface coating Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying - New trends in coating technology – DLC – CNC – Thick coatings – Nanoengineered coatings – Other coatings, Corrosion resistant coatings	
UNIT V – ENGINEERING MATERIALS	**(9)**
Introduction – High and low friction materials - Advanced alloys – Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys – Ceramics – Polymers – Biomaterials – Bio Tribology -Nano Tribology	
TOTAL : 45 PERIODS	

TEXT BOOKS:

1. G.W .Stachowiak and A.W.Batchelor, "Engineering Tribology", Butterworth-Heinemann, 2005.
2. S.K. Basu, S.N.Sengupta and B.B.Ahuja ,"Fundamentals of Tribology", Prentice Hall of India, 2005.

REFERENCES:

1. Fontana G., "Corrosion Engineering", McGraw Hill, 1985.
2. H Illing, J. (Editor), "Principles of Tribology ", MacMillian, 1984.
3. Rabinowicz.E., "Friction and Wear of materials", John Willey &Sons,1995.
4. Williams J.A., "Engineering Tribology", Oxford University Press, 1994.
5. Joseph R. Davis, Corrosion: Understanding the Basics, ASM International, 2000.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3												1	
2	3												1	
3		3											1	
4			1										1	
5										1			1	
CO (W.A)	3	3	1							1			1	

22MEX47 – GREEN SUPPLY CHAIN MANAGEMENT

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:	• To familiar the various standards and legislation of modern green electronic manufacturing. • To know the conventional electronic processing and lead-free electronic manufacturing techniques. • To recognize the steps involved in assembly process and understand the need of recycle the electronics • To implement reliability and product life cycle estimation tools in green electronic manufacturing. • To demonstrate the green electronic manufacturing procedure in real time applications.

Course Outcomes The Student will be able to		**Cognitive Level**	**Weightage of COs in End Semester Examination**
CO1	Apply fundamentals to concise awareness of standards and legislation of modern electronic manufacturing for green environment.	Ap	20%
CO2	Optimize the conventional electronic processing and lead free electronic manufacturing techniques.	An	20%
CO3	Design and realize the assembly process and the need of recycle in electronics.	Ap	40%
CO4	Analyze reliability and product life cycle estimation tools for green electronic manufacturing.	An	20%
CO5	Validate the green electronic manufacturing procedures in real time applications.	An/ Cr	Internal Assessment

UNIT I - INTRODUCTION TO GREEN ELECTRONICS	**(9)**
Environmental concerns of the modern society- Overview of electronics industry and their relevant regulations in China, European Union and other key countries- global and regional strategy and policy on green electronics industry. Restriction of Hazardous substances (RoHS) - Waste Electrical and electronic equipment (WEEE) - Energy using Product (EuP) and Registration - Evaluation, Authorization and Restriction of Chemical substances (REACH).	
UNIT II - GREEN ELECTRONICS MATERIALS AND PRODUCTS	**(9)**
Basics of IC manufacturing and its process – Electronics with Lead (Pb) – free solder pastes, conductive adhesives, Introduction to green electronic materials and products - halogen-free substrates and components. Substitution of non-recyclable thermosetting polymer based composites with recyclable materials X-Ray Fluorescence (XRF) for identifying hazardous substances in electronic products.	

UNIT III - GREEN ELECTRONICS ASSEMBLY AND RECYCLING	(9)
Various processes in assembling electronics components - the life-cycle environmental impacts of the materials used in the processes - substrate interconnects. Components and process equipments - Technology and management on e-waste recycle system construction, global collaboration, and product disassembles technology. Sustainable Electronics Materials in PCB Manufacturing – Restriction of Hazardous Substances Directive in PCB Assembly.	
UNIT IV - PRODUCT DESIGN AND SUSTAINABLE ECO-DESIGN	**(9)**
Stages of product development process in green design: Materials- Manufacturing - Packaging and use - End of Life and disposal - Design for recycling - Life Cycle Assessment (LCA), and Eco-design tools - Environmental management systems, and International standards - Eco-design in electronics industry.	
UNIT V - CASE STUDIES	**(9)**
Reliability of green electronics systems , Reuse and recycle of End-of-Life(EOL) electrical and electronic equipment for effective waste management – Introduction of Green Supply Chain, and Modeling green products from Supply Chain point of view - A life-cycle assessment for eco-design of Cathode Ray Tube Recycling. Case studies on Green Supply Chains and Enabling RFID Technology, Healthcare, Aerospace, GSCM and construction industry.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. Green Supply Chain Management, by Charisios Achillas , Dionysis D. Bochtis , Dimitrios Aidonis, Routledge; 1st edition (16 November 2018), ISBN-10 : 1138644617
2. Sammy G. Shina, Green Electronics Design and Manufacturing, McGraw Hill., 2008.

REFERENCES:

1. David Austen, Green Electronic Morning, Ingleby Gallery, 2006.
2. John Hu. Mohammed Ismail, CMOS High Efficiency on – Chip Power Management, Springer Publications 4th edition, 2011.
3. Yuhang yang and Maode Ma, Green Communications and Networks, Springer Publication., 2014.
4. Sanka Ganesan, Michael Pecht, Lead free Electronics, John Wiley & Sons, 2006.
5. Charles A. Harper, Electronic Materials and Processes Hand book, McGraw-Hill, 2010.
6. Sammy G. Shina, Green Electronics Design and Manufacturing, McGraw Hill., 2008.

Mapping of COs with POs / PSOs

	POs												PSOs	
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3		3										2	
2											3			
3		2					3							
4														
5														
CO (W.A)	**3**	**2**	**3**				**3**				**3**		**2**	

22MEX48 - PRODUCT LIFE CYCLE MANAGEMENT

L	T	P	C
3	0	0	3

PREREQUISITE : Nil

Course Objective:

- To study about the history, concepts and terminology in PLM
- To learn the functions and features of PLM/PDM
- To develop different modules offered in commercial PLM/PDM tools
- To demonstrate PLM/PDM approaches for industrial applications
- To use PLM/PDM

Course Outcomes The Student will be able to		Cognitive Level	Weightage of COs in End Semester Examination
CO1	Summarize the history and apply the concepts and terminology of PLM.	Ap	30%
CO2	Apply the features of PLM/PDM.	Ap	30%
CO3	Analyze the different modules offered in commercial PLM/PDM tools.	Ap	20%
CO4	Design PLM/PDM for industrial applications.	An	20%
CO5	Engage independent study as a member of team and make effective oral presentation on the application of PLM	U	Internal Assessment

UNIT I - INTRODUCTION TO PRODUCT LIFECYCLE MANAGEMENT	**(9)**
Introduction to PLM, Fundamentals of PLM- Objective of PLM -Activities of PLM -Joined-up and Holistic Approach - Generic Product Lifecycle Phases, PLM Grid, Components of PLM Grid, Why PLM, How PLM.	
UNIT II - COMPLEX AND CHANGING ENVIRONMENT	**(9)**
Changes and Interconnections, Macroeconomic and Geopolitical Changes, Environmental and Social Changes, Corporate Changes, Technological Changes, Product Changes, The Result and the Requirements	
UNIT III - PLM DEPLOYMENT AND BUSINESS BENEFITS	**(9)**
Deployment Stages of PLM, PLM maturity model, Realization stage of the project, Accomplishing change, Business benefits of a PLIM system -Factors leading to PLM, Benefits of the PLM system, Improving the productivity of labour, Costs of quality, PLM and data warehousing as a tool to support decision-making	
UNIT IV - SERVICE INDUSTRY AND PLM	**(9)**
Introduction to service, Further productization of services, Making a service, PLM in service business - PLM challenges in service business, Services modularization, Making items out of product functions, IT specifically variable product.	
UNIT V – PRODUCT AND PRODUCT MANAGEMENT STRATEGY AS A PART OF BUSINESS STRATEGY	**(9)**
Product lifecycle management as a business strategy tool, From changes in the business environment to product strategy, Making a product strategy, Product management strategy, Time to market, Time to react, Time to volume, Time to service, Electronic business and PLM	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:

1. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
2. AnttiSaaksvuori and AnselmiImmonen, "Product Lifecycle Management", Springer Publisher, 2008 (3rd Edition)

REFERENCES:

1. International Journal of Product Lifecycle Management, Inderscience Publishers
2. Ivica Cmkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating ProductData
3. Management and Software Configuration Management", Art ech House Publishers, 2003.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1													1	
2	3												1	
3		3											1	
4			1										1	
5										1			1	
CO (W.A)	3	3	1							1			1