MECHANICAL ENGINEERING
B.Tech. / B.Sc. (Engineering)

FLEXIBLE CURRICULUM / NEP 2020
(For students admitted in 2025 onwards)

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015
TAMIL NADU, INDIA.

VISION OF THE INSTITUTE
To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry
MISSION OF THE INSTITUTE
• To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
• To create a converging learning environment to serve a dynamically evolving society.
• To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
• To be an intellectual ecosystem where human capabilities can develop holistically.
VISION OF THE DEPARTMENT
To be a globally renowned Department in Mechanical Engineering where the best of teaching, learning and research synergize to fulfil the requirements of industry and society.
MISSION OF THE DEPARTMENT
• To prepare effective and responsible engineers for global requirements by providing quality education through graduate, post graduate and doctoral research programmes.
• To constantly strive to improve the teaching and learning processes by adopting innovative pedagogical methods.
• To respond effectively to the needs of the industry and society by offering sustainable and innovative solutions.
• To conduct basic and interdisciplinary research to publish in reputed international journal and to generate intellectual property.
• To provide consultancy services and cultivate the spirit of entrepreneurship.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Graduates will be successful Mechanical Engineers in the industry or in technical or professional career.
PEO2	Graduates will continue to constantly learn the emerging technology and advanced field of study.
PEO3	Graduates will be able to take up leadership positions in interdisciplinary technological activities.

PROGRAMME OUTCOMES (POs)

PO1	Apply knowledge of mathematics, science and engineering to arrive solutions for mechanical engineering problems.
PO2	Identify, formulate and analyze engineering problems through technical literature.
PO3	Design a component, a process and a system to meet desired needs considering economic, environmental, social, ethical, health and safety, manufacturability and sustainability.
PO4	Conduct experiment, analyze and interpret data to arrive valid conclusions.
PO5	Use the techniques, skills, and modern engineering tools for modelling and prediction of problems by understanding the limitations.
PO6	Recognize the importance of health and safety, societal, cultural responsibility in the design and implementation of engineering projects.
PO7	Know and apply societal and environmental context to engineering solutions for sustainable development.
PO8	Apply the standards and professional ethics in engineering practice.
PO9	Function effectively as a member or leader of a team.
PO10	Express effectively, comprehend and write reports on the engineering activities.
PO11	Apply engineering and management principles to manage projects in multidisciplinary environments.
PO12	Engage themselves in life-long learning by recognizing the need and technological changes.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1	Apply the fundamental knowledge acquired in the area of design, thermal engineering and manufacturing to identify, formulate and solve mechanical engineering problems confronted by the industry and society.
PSO2	Develop products and processes by carrying out research and development considering the economic constraints, sustainability, environment, safety, and cultural perceptions.

CURRICULUM FRAMEWORK AND CREDIT SYSTEM FOR THE FOUR-YEAR B.Tech. and 3 Year B.Sc. (Engineering) PROGRAMME

COURSE STRUCTURE

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirements)	22	56	34.4
PC (Programme Core)	15	55	33.7
Programme Elective (PE) / Open Elective (OE)	12	36	22.1
Essential Laboratory Requirements (ELR)	8 Maximum 2 per session up to 6th semester	16	9.8
Total	**57**	**163**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honors (Optional)	Courses for 15 credits	15 Additional credits	-

1. A minimum of seven Programme Core, each carrying 4 credits (II, III, IV, V, VI Semester).
2. Out of the 12 elective courses (PE / OE), students must complete at least eight Programme Electives (PE).
3. For a Minor Degree (MI), students must earn 15 credits in addition to the credit specified by the departments (160 credits), with the details of the Minor only mentioned on the transcript, not the degree certificate.
4. To qualify for an Honours Degree (HO), students must:
   (a) register for at least 12 theory courses and 2 ELRs in their second year,
   (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions,
   (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses,
   (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and
   (e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.
5. Project work is compulsory for B.Tech. programme. However, those students' wish to carry out the intern outside the institute (8th semester) can opt for two electives courses equivalent to 6 credits. But the project work is compulsory for B. Tech. (Honours) degree.

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech.

Semester	GIR		PC		ELR		PE/OE		Total	Credit
	Course	Credit	Course	Credit	Course	Credit	Course	Credit	Credits	Distribution
I	7	19	-	-	-	-	-	-	**19**	**40**
II	8	17	1	4	-	-	-	-	**21**	
III	-	-	4	15	2	4	2	6	**25**	**50**
IV	1	4	3	11	2	4	2	6	**25**	
V	1	3	4	15	2	4	1	3	**25**	**49**
VI	2	4	3	10	2	4	2	6	**24**	
VII	2	3	-	-	-	-	4	12	**15**	**24**
VIII	1	6	-	-	-	-	1	3	**9**	
Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

CURRICULUM FRAMEWORK / FLEXIBLE CURRICULUM / NEP 2020 /NCrF / B.Sc. (Engineering)

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credi	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	**I**	7	19	-	-	-	-	-	-	**19**	**40**
	II	8	17	1	4	-	-	-	-	**21**	
	III	-	-	4	15	2	4	2	6	**25**	**50**
	IV	1	4	3	11	2	4	2	6	**25**	
B.Sc. Exit	**V**	1	3	2	8	2	4	2	6	**21**	**37**
	VI	4[#]	12	-	-	2	4	-	-	**16**	
After B.Sc. exit and join back for B. Tech.	**VII**	-	-	3	11	-	-	3	9	**20**	**36**
	VIII	1	1	2	6	-	-	3	9	**16**	
	Total	**22**	**56**	**15**	**56**	**8**	**16**	**12**	**36**	**163**	**163**

[#](Summer internship (2), Project Work (6), Professional Ethics (3), and Industrial Lecture (1))

GENERAL INSTITUTE REQUIREMENTS (GIR) COURSES

Sl. No.	Course	Number of Courses	Max. Credits
1.	Mathematics	3	10
2.	Physics	1	3
	Physics Laboratory	1	2
3.	Chemistry	1	3
	Chemistry Laboratory	1	2
4.	Industrial Economics and Foreign Trade	1	3
5.	English for Communication	1	4
6.	Energy and Environmental Engineering	1	2
7.	Professional Ethics	1	3
8.	Engineering Graphics	1	3
9.	Engineering Practice	1	2
10.	Basic Engineering	2	4
11.	Introduction to computer Programming	1	3
12.	Branch Specific Course (Introduction to the Branch of study)	1	2
13.	Summer Internship	1	2
14.	Project work	1	6
15.	Comprehensive viva	1	1
16.	Industrial Lecture	1	1
17.	NSS/NCC/NSO	1	Pass / Fail
Total		**22**	**56**

Curriculum Framework and Credit System (Mechanical Engineering) / 163

Semester I (July Session)

Sl. No.	Course	Credits	Category
1.	English for Communication (Theory & Laboratory)	4	GIR
2.	Matrices and Calculus	3	GIR
3.	Chemistry	3	GIR
4.	Branch Specific Course	2	GIR
5.	Basics of Electrical and Electronics Engineering	2	GIR
6.	Engineering Graphics	3	GIR
7.	Chemistry Laboratory	2	GIR
	Total	**19**	

Semester II (January Session)

Sl. No.	Course	Credits	Category
1.	Complex Analysis and Differential Equations	3	GIR
2.	Physics	3	GIR
3.	Introduction to Computer Programming	3	GIR
4.	Basics of Civil Engineering (**for CL, ME, MT, PR**)	2	GIR
5.	Energy and Environmental Engineering	2	GIR
6.	Engineering Practice	2	GIR
7.	Physics Laboratory	2	GIR
8.	NSS/NCC/NSO	0	GIR
9.	Engineering Mechanics	4	PC
	Total	**21**	

Semester III (July Session)

Sl. No.	Course	Credits	Category
1.	Engineering Thermodynamics	4	PC
2.	Applied Electrical and Electronics Engineering	4	PC
3.	Fluids Mechanics and Machinery	4	PC
4.	Mechanics of Solids	3	PC
5.	Programme Elective–I	3	PE
6.	Programme Elective–II	3	PE
7.	Strength of Materials and Fluid Mechanics Laboratory	2	ELR
8.	Computer Aided Design Lab	2	ELR
	Total	**25**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 25 credits.

Semester IV (January Session)

Sl. No.	Course	Credits	Category
1.	Fourier transforms and Numerical techniques	4	GIR
2.	Manufacturing Technology	4	PC
3.	Thermal Engineering	4	PC
4.	Mechanics of Machines – I	3	PC
5.	Programme Elective–III	3	PE
6.	Programme Elective–IV / Open Elective–I	3	PE/OE
7.	Thermal Engineering Laboratory	2	ELR
8.	Manufacturing Technology Laboratory	2	ELR
	Total	**25**	

Semester V (July Session) / Continuing B.Tech.

Sl. No.	Course	Credits	Category
1.	Professional Ethics	3	GIR
2.	Engineering Materials	4	PC
3.	Heat and Mass Transfer	4	PC
4.	Mechanics of Machines – II	4	PC
5.	Metrology and Measurements	3	PC
6.	Programme Elective–V/Open Elective–II	3	PE/OE
7.	Heat transfer and Refrigeration & Air-Conditioning Laboratory	2	ELR
8.	Metrology and Measurements Laboratory	2	ELR
	Total	**25**	

Semester V (July Session) / B.Sc. (Engineering) Exit

Sl. No.	Course	Credits	Category
1.	Professional Ethics	3	GIR
2.	Engineering Materials	4	PC
3.	Heat and Mass Transfer	4	PC
4.	Programme Elective–V	3	PE
5.	Programme Elective-VI / Open Elective–II	3	PE/OE
6.	Heat transfer and Refrigeration & Air-Conditioning Laboratory	2	ELR
7.	Metrology and Measurements Laboratory	2	ELR
	Total	**21**	

Semester VI (January Session)

Sl. No.	Course	Credits	Category
1.	Industrial Lecture	1	GIR
2.	Industrial Economics and Foreign Trades	3	GIR
3.	Design of Machine Elements	4	PC
4.	Automobile Engineering	3	PC
5.	Energy Conversion systems	3	PC
6.	Programme Elective–VI	3	PE
7.	Programme Elective–VII / Open Elective –III	3	PE/OE
8.	Dynamics Laboratory	2	ELR
9.	Automobile Engineering Laboratory	2	ELR
	Total	**24**	

Semester VI (January Session) /B.Sc. (Engineering) Exit

Sl. No.	Course	Credits	Category
1.	Project Work	6	GIR
2.	Winter Internship	2	GIR
3.	Industrial Lecture	1	GIR
4.	Industrial Economics and Foreign Trades	3	GIR
5.	Dynamics Laboratory	2	ELR
6.	Automobile Engineering Laboratory	2	ELR
	Total	**16**	

Semester VII (July Session)

Sl. No.	Course	Credits	Category
1.	Summer Internship*	2	GIR
2.	Comprehensive Viva Voce	1	GIR
3.	Programme Elective–VIII	3	PE
4.	Programme Elective–IX	3	PE
5.	Programme Elective–X / Open Elective–IV	3	PE/OE
6.	Programme Elective–XI / Open Elective–V	3	PE/OE
	Total	**15**	

** Evaluation for Summer Internship*

Semester VII (July Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course	Credits	Category
1.	Mechanics of Machines – II	4	PC
2.	Metrology and Measurements	3	PC
3.	Design of Machine Elements	4	PC
4.	Programme Elective–VII	3	PE
5.	Programme Elective–VIII	3	PE
6.	Programme Elective–IX / Open Elective – III	3	PE/OE
	Total	20	

Semester VIII (January Session)

Sl. No.	Course	Credits	Category
1.	Programme Elective–XII / Open Elective–IV	3	PE/OE
2.	Project Work	**6**	GIR
	Total	**9**	

Semester VIII (January Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

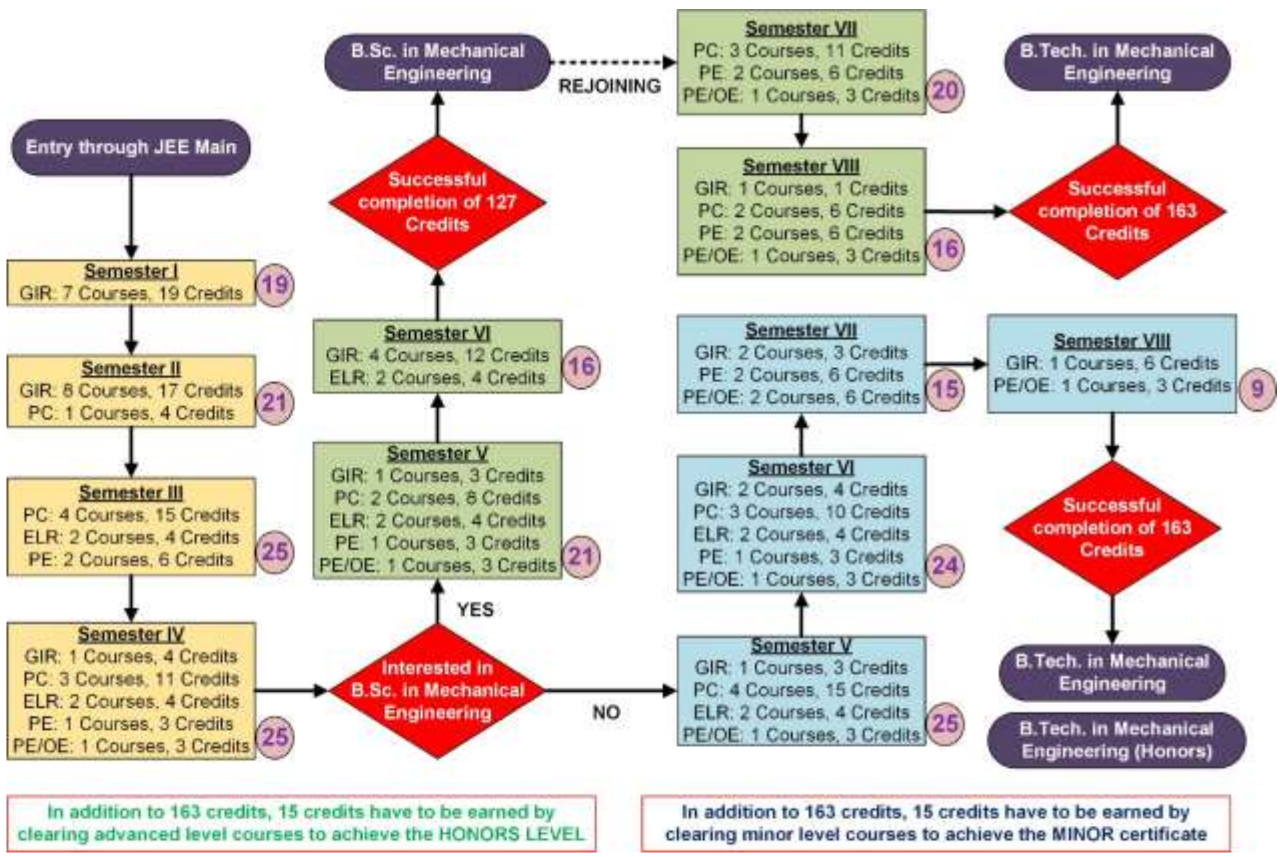
Sl. No.	Course	Credits	Category
1.	Comprehensive Viva Voce	1	GIR
2.	**Automobile Engineering**	**3**	**PC**
3.	**Energy Conversion systems**	**3**	**PC**
4.	Programme Elective–X	3	PE
5.	Programme Elective–XI	3	PE
6.	Programme Elective–XII/ Open Elective–IV	3	PE/OE
	Total	**16**	

Semester	I	II	III	IV	V	VI	VII	VIII	Total
B.Tech.	19	21	25	25	25	24	15	9	**163**
B.Sc.	19	21	25	25	21	16	20	16	**163**

Note:

1. The curriculum should have **7** Programme Core (PC) courses shall be of **4** credits each.
2. Out of 12 elective courses (PE/OE), the students should study at least eight programme elective courses (PE).
3. Minor (MI): 15 credits over and above the minimum credit as specified by the departments (163). The details of MINOR will be mentioned in the transcript and in the Degree certificate.
4. Honours (HO): 15 credits over and above the minimum credit as specified by the departments (163).

Flowchart for B. Tech & B.Sc. (Engineering) Degree Requirements



ELECTIVES CHOICES

Option 1 / Regular B.Tech.

To get a B.Tech. degree in **Mechanical Engineering**, possible choices of electives in Programme Electives and Open Electives are,

Program Electives	Open Electives	Total
8	4	12
9	3	12
10	2	12
11	1	12
12	0	12

Option 2 / B.Sc. (Engineering) Exit (at end of 3rd year)

Program Electives	Open Electives	Total
3	2	5
4	1	5
5	0	5

Option 3 / B.Tech. with Minor

To get a B.Tech. degree in **Mechanical Engineering** and minor in other programmes, possible choices of electives in Programme Electives, Open Electives and Minor Electives are,

Program Electives	Open Electives	Minor Electives	Total
8	4	5	12 + 5
9	3	5	12 + 5
10	2	5	12 + 5
11	1	5	12 + 5
12	0	5	12 + 5

Option 4 / B.Tech. with Honours

To get a B.Tech. Honors degree in **Mechanical Engineering**, possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Total
8	4	4	12 + 4
9	3	4	12 + 4
10	2	4	12 + 4
11	1	4	12 + 4
12	0	4	12 + 4

Option 5 / B.Tech. with Honours and Minor

To get a B.Tech. Honors degree in **Mechanical Engineering** and minor in other programmes possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Minor Electives	Total
8	4	4	5	12 + 4 + 5
9	3	4	5	12 + 4 + 5
10	2	4	5	12 + 4 + 5
11	1	4	5	12 + 4 + 5
12	0	4	5	12 + 4 + 5

Note: No Minor or Honours will be awarded for B.Sc. But students can credit minors and honours during the 6 semesters and redeem it to obtain a minor or honours after rejoining and completing B.Tech. Also, B.Sc. students shall only do programme electives in place of their project work in 6th semester.

LIST OF COURSES

(I) PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEPC10	Engineering Mechanics	NIL	4
2.	MEPC11	Engineering Thermodynamics	NIL	4
3.	MEPC12	Applied Electrical and Electronics Engineering	EEIR11	4
4	MEPC15	Fluid Mechanics and Machinery	MEPC10	4
5.	MEPC14	Mechanics of Solids	NIL	3
6.	MEPC13	Manufacturing Technology	NIL	4
7.	MEPC16	Thermal Engineering	MEPC11	4
8.	MEPC17	Mechanics of Machines – I	MEPC10	3
9.	MEPC18	Engineering Materials	NIL	4
10.	MEPC19	Heat and Mass Transfer	MAIR32 MEPC11 MEPC15	4
11.	MEPC20	Mechanics of Machines – II	MEPC17	4
12.	MEPC21	Metrology and Measurements	NIL	3
13.	MEPC22	Design of Machine Elements	MEPC14 MEPC17	4
14.	MEPC23	Automobile Engineering	NIL	3
15.	MEPC24	Energy Conversion systems	MEPC16	3

(II) ELECTIVES

a. PROGRAMME ELECTIVES

Stream I (Thermal Engineering)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEPE33	Biofuels	NIL	3
2.	MEPE34	Renewable Energy Sources	NIL	3
3.	MEPE43	Advanced IC Engines	MEPC16	3
4.	MEPE52	Compressible Flow and Jet Propulsion	MEPC16	3
5.	MEPE61	Refrigeration and Air Conditioning	MEPC16	3
6.	MEPE62	Computational Fluid Dynamics	MEPC15	3
7.	MEPE65	Convective Heat Transfer	MEPC11	3
8.	MEPE72	Power Plant Engineering	MEPC16	3
9.	MEPE74	Cryogenic Engineering	MEPC16	3
10.	MEPE84	Fundamentals of HVAC Systems	MEPC16	3
11.	MEPE85	Alternative Refrigerants	MEPC16	3

Stream II (Design Engineering)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEPE31	Computer Aided Design and Drafting	NIL	3
2.	MEPE35	Machine Drawing	NIL	3
3.	MEPE36	Introduction to AI & ML for Applications in Mechanical Engineering	NIL	3
4.	MEPE42	Continuum Mechanics	MEPC14	3
5.	MEPE51	Advanced Mechanics of Solids	MEPC14	3
6.	MEPE63	MEMS Devices – Design and Fabrication	MEPC14	3
7.	MEPE64	Mechanical Vibration and Acoustics	MEPC20	3
8.	MEPE71	Finite Element Method	MEPC14	3
9.	MEPE75	Vehicle Dynamics	MEPC20	3
10.	MEPE76	Fundamentals of Biomechanics	MEPC10	3
11.	MEPE77	Mechanics of Composite Materials	MEPC14	3
12.	MEPE82	Introduction to Fracture Mechanics	MEPC14	3
13.	MEPE83	Dynamics of Machinery	MEPC20	3

Stream III (Industrial and Manufacturing Engineering)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEPE32	Industrial Safety Engineering	NIL	3
2.	MEPE41	Mechatronics	NIL	3
3.	MEPE44	Additive Manufacturing	MEPC13	3
4.	MEPE45	Industrial Tribology	MEPC18	3
5.	MEPE53	Operations Research	NIL	3
6.	MEPE73	Fundamentals of Robotics	MEPC17	3
7.	MEPE78	Advanced Automotive Technology	MEPC23	3
8.	MEPE81	Quality Control	NIL	3

b. OPEN ELECTIVE (OE)

The courses listed below are offered by the Department of Mechanical Engineering for students of all Departments.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEOE10	Smart Materials and Structures	NIL	3
2.	MEOE11	Optimization in Engineering Design	NIL	3
3.	MEOE12	Energy Conservation and Management	NIL	3
4.	MEOE13	Energy Storage Technology	NIL	3
5.	MEOE14	Low Temperature Technology	NIL	3
6.	MEOE15	Waste to Energy Conversion Techniques	NIL	3
7.	MEOE16	Non-Destructive Testing	NIL	3
8.	MEOE17	Pollution and Control	NIL	3
9.	MEOE18	Welding Technology	NIL	3
10.	MEOE19	Finite Element Method for Engineers	NIL	3
11.	MEOE20	Computational Methods in Engineering	NIL	3
12.	MEOE21	Elementary Continuum Mechanics	NIL	3
13.	MEOE22	Modern Automotive Technology	NIL	3
14.	MEOE23	Hydrogen – Production Handling and Storage	NIL	3
15.	MEOE24	Engineering Product Realization	NIL	3

c. MINOR(MI) (offered for the students of other departments)

Students of other departments who desire B.Tech. Minor in **Mechanical Engineering** can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEMI10	Basic Thermodynamics	NIL	3
2.	MEMI11	Fundamentals of Thermal Engineering	NIL	3
3.	MEMI12	Fluid Mechanics and Machinery	NIL	3
4.	MEMI13	Fundamentals of Heat and Mass Transfer	NIL	3
5.	MEMI14	Fundamentals of Automotive Technology	NIL	3
6.	MEMI15	Fundamentals of Refrigeration and Air Conditioning	NIL	3
7.	MEMI16	Principles of Turbomachinery	NIL	3
8.	MEMI17	Fundamentals of Internal Combustion Engines	NIL	3
9.	MEMI18	Engine Pollution and Control	NIL	3
10.	MEMI19	Fundamentals of Dynamics	NIL	3
11.	MEMI20	Fundamentals of Mechanical Design	NIL	3

(III) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MELR11	Manufacturing Technology Laboratory	NIL	2
2.	MELR12	Computer Aided Design Lab	NIL	2
3.	MELR13	Thermal Engineering Laboratory	NIL	2
4.	MELR14	Strength of Materials and Fluid Mechanics Laboratory	NIL	2
5.	MELR15	Heat Transfer and RAC Laboratory	NIL	2
6.	MELR16	Metrology and Measurements Laboratory	NIL	2
7.	MELR17	Dynamics Laboratory	NIL	2
8.	MELR18	Automobile Engineering Laboratory	NIL	2

IV. ONLINE COURSES (OC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEOC51	Automation Engineering	NIL	3
2.	MEOC52	Functional and Conceptual Design	NIL	3
3.	MEOC53	Heat Exchangers: Fundamentals and Design Analysis	NIL	3
4.	MEOC54	Introduction to Aerospace Engineering	NIL	3
5.	MEOC55	Introduction to Airbreathing Propulsion	NIL	3
6.	MEOC56	Introduction to Mechanical Vibration	NIL	3
7.	MEOC57	Introduction to Robotics	NIL	3
8.	MEOC58	Lighter than Air Systems	NIL	3
9.	MEOC59	Rocket Propulsion	NIL	3
10.	MEOC60	Experimental Methods in Fluid Mechanics	NIL	3
11.	MEOC61	Fundamentals of Automotive Systems	NIL	3
12.	MEOC62	Solar Energy Engineering and Technology	NIL	3
13.	MEOC63	Computer Integrated Manufacturing	NIL	3
14.	MEOC64	Fundamentals of Compressible flow	NIL	3
15.	MEOC65	Wheeled Mobile Robots	NIL	3
16.	MEOC66	Leadership and Team effectiveness	NIL	3
17.	MEOC67	Deep Learning	NIL	3
18.	MEOC68	Entrepreneurship Essentials	NIL	3
19.	MEOC69	Six Sigma	NIL	3
20.	MEOC70	Deep Learning for Computer Vision	NIL	3
21.	MEOC71	Understanding Incubation and Entrepreneurship	NIL	3
22.	MEOC72	Automation in manufacturing	NIL	3
23.	MEOC73	Industrial Robotics: Theories For Implementation	NIL	3
24.	MEOC74	Manufacturing Systems Technology I & II	NIL	3
25.	MEOC75	Mathematical Modeling of Manufacturing Processes	NIL	3
26.	MEOC76	Entrepreneurship	NIL	3
27.	MEOC77	Aerodynamic Design of Axial Flow Compressors & Fans	NIL	3
28.	MEOC78	Machine Learning and Deep Learning - Fundamentals and Applications	NIL	3
29.	MEOC79	Applied Thermodynamics	NIL	3
30.	MEOC80	Introduction to Astrophysical Fluids	NIL	3
31.	MEOC81	Introduction to Laser	NIL	3
32.	MEOC82	Applied Optics	NIL	3
33.	MEOC83	Scientific Computing using python	NIL	3
34.	MEOC84	Introduction to Classical Mechanics	NIL	3
35.	MEOC85	Modern Engineering Materials	NIL	3
36.	MEOC86	Product Design and Manufacturing	NIL	3

Sl. No.	Course Code	Course Title	Prerequisites	Credits
37.	MEOC87	Fluid Dynamics for Astrophysics	NIL	3
38.	MEOC88	Thermal Physics	NIL	3
39.	MEOC89	Plasma Physics and Applications	NIL	3
40.	MEOC90	Fundamentals of Theoretical and Experimental Aerodynamics	NIL	3
41.	MEOC91	Viscous Fluid Flow	NIL	3
42.	MEOC92	Advanced Fluid Mechanics	NIL	3
43.	MEOC93	Computational Fluid Dynamics	NIL	3
44.	MEOC94	IC Engines and Gas Turbines	NIL	3
45.	MEOC95	Nonlinear Control Design	NIL	3
46.	MEOC96	Industrial Hydraulics and Automation	NIL	3
47.	MEOC97	Optimization from fundamentals	NIL	3
48.	MEOC98	Machinery Fault Diagnosis and Signal Processing	NIL	3

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEHO10	Advanced Heat Transfer	MEPC19	4
2.	MEHO11	Advanced Fluid Mechanics	MEPC15	4
3.	MEHO12	Advanced Engineering Materials	MEPC18	4
4.	MEHO13	Design of Heat Exchangers	MEPC19	4
5.	MEHO14	Design and Optimization of Thermal Energy Systems	MEPC19	4
6.	MEHO15	Fuels Combustion and Emission Control	MEPC16	4
7.	MEHO16	Advanced Computational Methods in Engineering	NIL	4
8.	MEHO17	Computational Continuum Mechanics	MEPC14	4
9.	MEHO18	Heat Transfer Equipment Design	MEPC19	4
10.	MEHO19	Analysis and Design of Pressure Vessels	MEPC14	4
11.	MEHO20	Design and Analysis of Turbo Machines	MEPC15	3
12.	MEHO21	Analysis of Thermal Power Cycles	MEPC16	3
13.	MEHO22	Boiler Auxiliaries and Performance Evaluation	NIL	3
14.	MEHO23	Environmental Pollution Control	NIL	3

VI. MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Sl. No.	Course Code	Course Title	Credit
1.	MEMC10	Peridynamics for Fracture Simulation	1
2.	MEMC11	3D Printing and Design Integration	1
3.	MEMC12	CAD Fundamentals for Mechanical Design	1
4.	MEMC13	AI for Automotive Technology	1
5.	MEMC14	Mechanical Testing of Materials	1
6.	MEMC15	Granular Mechanics	1
7.	MEMC16	Introduction to Vehicle Noise and Vibration Control	1
8.	MEMC17	Melting and Solidification of Metals	1
9.	MEMC18	Future Fuels	1
10.	MEMC19	Introduction to Bioinspired Robotics	1

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

PROGRAMME CORE (PC) – 1/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPC10	**Engineering Mechanics**	CO1	3	2	1		3	2	2	1		3	2	3	3	2
		CO2	3	3	3		3	2	2	2		3	2	3	3	3
		CO3	3	2	3		3	2	2	2		3	2	3	3	3
		CO4	3	2	1		3	2	1	2		3	2	3	3	3
		CO5	3	3	3		3	2	2	2		3	2	3	3	3
MEPC11	**Engineering Thermodynamics**	CO1	3	3				3	3					3		
		CO2	3	3		3		3	3		3			3		
		CO3	3	3		3		3	3					3		
		CO4	3	3		3		3	3					3		
		CO5	2			2		3	2		3			3		
MEPC12	**Applied Electrical and Electronics Engineering**	CO1	3	2	1	1	2	1	1	1	2	2	1	3	2	1
		CO2	3	1	3	1	1	1	1	1	3	2	2	3	2	1
		CO3	3	3	3	2	3	1	1	1	1	2	1	3	2	1
		CO4	2	1	2	2	3	1	1	1	1	2	1	3	2	1
		CO5	3	1	3	1	1	1	1	1	3	2	2	3	2	1
MEPC15	**Fluid Mechanics and Machinery**	CO1	3	3	1	1	2	1	3	3	1	3	1	1	3	3
		CO2	3	3	1	1	2	1	3	3	1	3	1	1	3	3
		CO3	3	3	1	1	2	1	3	3	1	3	1	2	3	3
		CO4	3	3	1	1	2	1	3	3	1	3	1	3	3	3
		CO5	3	3	2	1	2	1	3	3	1	3	2	3	3	3
MEPC14	**Mechanics of Solids**	CO1	3	3	3		2			3		2	1	3	3	2
		CO2	3	2	1		2			3		2	1	3	3	1
		CO3	2	2	1		2			3		2	1	3	3	
		CO4	3	2	2		2			3		2	1	3	3	
		CO5	2	3	2		1		1	3		2	1	3	3	1

3 - High; 2 - Medium; 1 - Low

PROGRAMME CORE (PC) – 2/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPC13	**Manufacturing Technology**	CO1	3	3	3			2	1	2		2		3	3	2
		CO2	3	3	3			2		2		2		3	3	2
		CO3	3	3	3			2		2		2		3	3	2
		CO4	3	3	3			2		2		2		3	3	2
		CO5	3	3	3		3	2		2		2		3	3	2
MEPC16	**Thermal Engineering**	CO1	3	2	2		1	3	2	3			2	3	3	3
		CO2	3	2	2		2	2	2	3			2	3	3	3
		CO3	3	2	2		2	3	3	2			2	3	3	3
		CO4	3	2	2		1	2	3	3			2	3	3	3
		CO5	3	2	2		1	2	3	3			2	3	3	3
MEPC17	**Mechanics of Machines - I**	CO1	3	3	2	1	1	2	3	3	2	1	1	3	3	2
		CO2	3	3	3	2	1	3	2	2	1	1	2	3	2	2
		CO3	3	3	1	2	1	2	3	3	3	2	1	3	2	2
		CO4	3	2	1	1	2	3	3	2	3	3	2	3	3	2
		CO5	3	3	2		1	2	3	2	2	3	2	3	3	2
MEPC18	**Engineering Materials**	CO1	3	3	1	3	3	1	2	2	1	2	1	3	2	2
		CO2	3	3	3	3	2	3	3	3	1	2	2	3	3	2
		CO3	2	3	3	3	3	2	2	3	3	2	2	3	3	3
		CO4	3	3	3	3	3	2	3	2	3	3	3	3	3	3
		CO5	3	3	3	3	3	2	3	3	3	2	2	3	3	3
MEPC19	**Heat and Mass Transfer**	CO1	3	3	3		3	3	2				1	3	3	3
		CO2	3	3	3		3	3	2				1	3	3	3
		CO3	3	3	3		3	3	3				1	3	3	3
		CO4	3	3	3		3	3	2				1	3	3	3
		CO5	3	3	3		3	3	3				1	3	3	3

3 - High; 2 - Medium; 1 - Low

PROGRAMME CORE (PC) – 3/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPC20	**Mechanics of Machines - II**	CO1	3	3	3		3	3	3					3		
		CO2	3	3	3		3	3	3					3		
		CO3	3	3	3		3	3	3					3		
		CO4	3	3	3		3	3	3					3		
		CO5	3	3	3		3	3	3					3		
MEPC21	**Metrology and Measurement**	CO1	3	3						3						
		CO2	3	3	3					3						
		CO3	3	3	3	3	2			3						
		CO4	3	3	3	3	2			3						
		CO5	3	3	3	3	2			3						
MEPC22	**Design of Machine Elements**	CO1	3	3	3		3	3	3	3						
		CO2	3	3	3			3		3				3		
		CO3	3	3	3		3			3	3		3	3		
		CO4	3	3	3		3	3	3	3		3	3	3		
		CO5														
MEPC23	**Automobile Engineering**	CO1	3	3	3	3	3	3	3						2	2
		CO2	3	3	3	3	3	3	3		3	3			3	
		CO3	3	3	3	3			3				3	3		
		CO4	3	3	3	3			3				3	3	1	
		CO5	3	3	3	3	3	3	3						2	2
MEPC24	**Energy Conversion systems**	CO1	3	3					3				3			
		CO2	3		3		3		3							
		CO3	3	3	3	3	3							3		
		CO4	3	3	3	3	3						3			
		CO5	3	3	3	3	3		3					3		

3 - High; 2 - Medium; 1 - Low

PROGRAMME ELECTIVES (PE) – Stream I - Thermal Engineering - 1/6

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE33	**Biofuels**	CO1	1	2	3	1	3	2	3	2			1	2	1	2
		CO2	1	3	3	1	3	2	3	2			1	2	1	3
		CO3	3	3	3	2	3	2	3	2			1	2	3	3
		CO4	2	3	3	2	3	2	3	2			1	2	2	3
		CO5	2	3	3	2	3	2	3	2			1	2	2	3
MEPE34	**Renewable Energy Sources**	CO1	2	2	3			3	3				3	3	2	
		CO2	3		3		3	3	2					3	1	1
		CO3	2	2					3					3	2	
		CO4	1	1	3		3	2					2			2
		CO5	2	2	3								1	2	1	1
MEPE43	**Advanced IC Engines**	CO1	3	3	3	3	3	3	3			2	2	2	3	3
		CO2	3	3	2	3	3	3	3			3	2	2	3	3
		CO3	3	3	2	3	3	3	3			3	2	2	3	3
		CO4	3	3	2	3	3	3	3			3	2	2	3	3
		CO5	3	3	2	3	3	3	3			3	3	3	3	3
MEPE52	**Compressible Flow and Jet Propulsion**	CO1	3	3	3	3	3					3	2	2	3	3
		CO2	3	3	3	3	3					3	2	2	3	3
		CO3	3	2	2	2	3					2	2	2	3	2
		CO4	3	3	3	3	3					3	2	2	3	3
		CO5	3	2	2	2	3					2	2	2	3	2
MEPE61	**Refrigeration and Air Conditioning**	CO1	3				3								2	
		CO2	3	3			3	3	3						2	1
		CO3		3			3								2	
		CO4	3	3											2	1
		CO5	3	3			3	3	3						2	1

3 - High; 2 - Medium; 1 - Low

PROGRAMME ELECTIVES (PE) – Stream I - Thermal Engineering - 2/6

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE62	**Computational Fluid Dynamics**	CO1	3	3	2		3	2	2			3	3	3	3	2
		CO2	3	3	2		3	2	2			3	3	3	3	2
		CO3	3	3	2		3	2	2			3	3	3	3	2
		CO4	3	3	2		3	2	2			3	3	3	3	2
		CO5	3	2	1		3	1	1			3	3	3	3	2
MEPE65	**Convective Heat Transfer**	CO1	3	2	2		3						3	2	3	2
		CO2	3	2	3		2						3	2	3	1
		CO3	3	2	1		3						3	3	3	2
		CO4	2	3	1		2						2	2	3	1
		CO5	3	2	3		3						3	2	3	1
MEPE72	**Power Plant Engineering**	CO1	2	2	2	2	2					3		3	3	2
		CO2	2	2	2	2	2					3		3	3	2
		CO3	3	2	2	3	3					3	3	2	3	2
		CO4	3	3	2	3	3					2	3	2	3	2
		CO5	3	3	2	3	3					3	3	2	3	2
MEPE84	**Cryogenic Engineering**	CO1	3	2											2	1
		CO2	3	2											2	
		CO3	3	2											1	1
		CO4			3		3								2	
		CO5	2				2			3			1			1
MEPE85	**Fundamentals of HVAC Systems**	CO1	3	2											2	1
		CO2	3	2												
		CO3	3	2											3	1
		CO4			3		3								1	
		CO5	2				2			3			1			1

3 - High; 2 - Medium; 1 - Low

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE85	**Alternative Refrigerants**	CO1	3	2											2	1
		CO2	2						3						2	
		CO3	2						3						1	1
		CO4			3		3								2	
		CO5	2		2		1		1				1			1

PROGRAMME ELECTIVES (PE) – Stream II - Design Engineering - 3/6

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE31	**Computer Aided Design and Drafting**	CO1	3	3	1		2	2	2	2		3	1	3	3	1
		CO2	3	3	1		2	2	2	2		3	1	3	3	1
		CO3	3	3	1		2	2	2	2		3	1	3	3	1
		CO4	3	2	2		3	2	1	2		3	2	3	3	3
		CO5	3	3	1	1	2	2	2	2		3	2	3	3	3
MEPE35	**Machine Drawing**	CO1	2	1	2		3			2		2		1		
		CO2	2	2	3		3			2		2		1		
		CO3	2	2	3	1	3				2	2	1	1		
		CO4	2	3	3		2	1	1	2		2	1	1		
		CO5	2	1	2		3				2	3	1	2		
MEPE36	**Introduction to AI & ML for Mechanical Engineering**	CO1	3	2	1	1	2			1		1		2	2	1
		CO2	3	3	1	2	2					1		2	3	1
		CO3	3	3	1	2	2					1		2	3	1
		CO4	2	2	1	1	3					1		2	2	1
		CO5	3	3	2	3	3	1	1	2	1	2	1	2	3	2
MEPE42	**Continuum Mechanics**	CO1	3	3	1		2	2	2	2		3	1	3	3	1
		CO2	3	3	1		2	2	2	2		3	1	3	3	1
		CO3	3	3	1		2	2	2	2		3	1	3	3	1
		CO4	3	2	2		3	2	1	2		3	2	3	3	3
		CO5	3	3	1	1	2	2	2	2		3	2	3	3	3

MEPE51	**Advanced Mechanics of Solids**	CO1	3	3	1		3							3	3	1
		CO2	3	3	1		3							3	3	1
		CO3	3	3	1		3							3	3	1
		CO4	3	3	1		3							3	3	1
		CO5	3	3	1		3							3	3	1
MEPE63	**MEMS Devices – Design and Fabrication**	CO1	3	2	2		3	2	3		2		3	3	2	2
		CO2	3	2	3		2	2	2		2		3	2	2	2
		CO3	3	3	3		3	2	3		2		3	3	2	2
		CO4	3	3	3		2	2	3		3	2	3	3	2	2
		CO5	3	3	3		1	2	3		3	2	3	3	2	2

PROGRAMME ELECTIVES (PE) – Stream II - Design Engineering - 4/6

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE64	**Mechanical Vibrations and Acoustics**	CO1	3	3			3	2						3	3	
		CO2	3	3			3	2						3	3	
		CO3	3	3			3	2						3	3	
		CO4	3	3			3	3						3	3	2
		CO5	3	3			3	3						3	3	2
MEPE71	**Finite Element Method**	CO1	3	3	1		2	2	2	2		3	1	3	3	1
		CO2	3	3	1		2	2	2	2		3	1	3	3	1
		CO3	3	3	1		2	2	2	2		3	1	3	3	1
		CO4	3	2	2		3	2	1	2		3	2	3	3	3
		CO5	3	3	1	1	2	2	2	2		3	2	3	3	3
MEPE75	**Vehicle Dynamics**	CO1	3	2	2		3	1	1					3	3	
		CO2	3	2	2		3	1	1					3	3	
		CO3	3	2	2		3	3	1					3	3	3
		CO4	3	2	2		3	3	1					3	3	3
		CO5	3	2	2		3	3	1					3	3	3
MEPE76	**Fundamentals of Biomechanics**	CO1	3	3	1		2	2	2	2		3	1	3	3	1
		CO2	3	3	1		2	2	2	2		3	1	3	3	1
		CO3	3	3	1		2	2	2	2		3	1	3	3	1
		CO4	3	2	2		3	2	1	2		3	2	3	3	3
		CO5	3	3	1	1	2	2	2	2		3	2	3	3	3
MEPE77	**Mechanics of Composite Materials**	CO1	3	3	2		3							3		
		CO2	3	3	2		3					2		3		
		CO3	3	3	2		3					2		3		
		CO4	3	3	2	2	3					2		3		
		CO5														

3 - High; 2 - Medium; 1 - Low

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE82	**Introduction to Fracture Mechanics**	CO1	3	3	2		3							3	3	3
		CO2	3	3	2		3							3	3	3
		CO3	3	3	2		3							3	3	3
		CO4	3	3	2	2	3							3	3	3
		CO5	3	3	2		3							3	3	3
MEPE83	**Dynamics of Machinery**	CO1	3	3		2	3					1				
		CO2	3	3	2	2	3	1				1				
		CO3	3	3		2	3		1	1		1		1		
		CO4	3	3	2	2	3			1		1		1		
		CO5	3	3	2	2	3	1	1	1		1		1		

PROGRAMME ELECTIVES (PE) – Stream III – Industrial & Manufacturing Engineering - 5/6

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE32	**Industrial Safety Engineering**	CO1														
		CO2														
		CO3														
		CO4														
		CO5														
MEPE41	**Mechatronics**	CO1		2			1	1				1			2	1
		CO2	3		3		3								3	2
		CO3	3		3		3								3	2
		CO4	3		3		3								3	2
		CO5		2								1			1	2
MEPE44	**Additive Manufacturing**	CO1	3	3	3	1	3	3	2	2	3		1	3	3	2
		CO2	2	1	3		3	1	1		1	2	1	3	3	3
		CO3	3	1	1	2	3	2	2	3		1	3	1	3	3
		CO4	1		2	1	3	2	2			2	3	1	3	3
		CO5	1	3	1	1	2	2	3			1	3	2	3	3

PROGRAMME ELECTIVES (PE) – Stream III – Industrial & Manufacturing Engineering - 6/6

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEPE45	Industrial Tribology	CO1		2				2	2			2			2	2
		CO2	2	2			2	2				2	2		2	2
		CO3	2	2			2	2				2	2		2	2
		CO4	2	2			2	2				2	2		2	2
		CO5	2	2			2	2				2	2		2	2
MEPE53	Operations Research	CO1	3	3	3		3									
		CO2	3	3	3		3									
		CO3	3	3	3		3									
		CO4	3	3	3		3									
		CO5	3	3	3		3									
MEPE73	Fundamentals of Robotics	CO1		2				1	1			1			3	1
		CO2	3		3		3								3	2
		CO3	3		3		3								3	2
		CO4	3		3		3								3	2
		CO5		2				1	1			1			1	2
MEPE78	Advanced Automotive Technology	CO1	3	1	2	3	3	1	1			2	2	2	2	2
		CO2	3	3	3	1	1	1	1	1		1	3	3	3	
		CO3	2	2	2	2	2	1	2	1		2	2	2		
		CO4	2	2	3	1	3	3	3	1	1	1	1	1	1	
		CO5	3	3	3	2	2	1	2	2	2	2	2	2		1
MEPE81	Quality Control	CO1	2	3	3	3	3	2		3	3	2		2		
		CO2	3	3	3	2	3		2		2	3	3	3		
		CO3	2	3	2		3					2		2		
		CO4	2	3	2		3					2		2		
		CO5														

3 - High; 2 - Medium; 1 - Low

OPEN ELECTIVES (OE) – 1/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEOE10	**Smart Materials and Structures**	CO1	3	3	3		1	3	3		3	2	2	3	3	3
		CO2	3	3	3		2	3	3		3	2	2	3	3	2
		CO3	3	3	3		3	3	3		3	2	2	3	3	2
		CO4	3	3	3		3	3	3		3	2	2	3	3	3
		CO5	3	3	3		3	3	3		3	2	2	3	3	1
MEOE11	**Optimization in Engineering Design**	CO1	2	2	1	2								1		
		CO2	2	2		2								1		
		CO3	2	3	2	2								1		
		CO4	1	1		2								1		
		CO5	2	3	1	2								2		
MEOE12	**Energy Conservation and Management**	CO1	2	2	3		2	2	2				3	3		
		CO2	3	3	2		3						2	2		
		CO3	3	3	2		2						2	3		
		CO4	2	3	3		3	1	2				3	2		
		CO5	3	3	2		3	2	2				3	2		
MEOE13	**Energy Storage Technology**	CO1	2	2	3			2	3				3	3		
		CO2	1		3		3	3	2	3		3		3		
		CO3	2	2					3	2	3			3		
		CO4	1	3	2		3	2					2			
		CO5	2	2	3		3	3		3		3	1	2		
MEOE14	**Low Temperature Technology**	CO1	3	2												
		CO2	3	2												
		CO3	3	2												
		CO4			3		3									
		CO5	2				2			3			1			

3 - High; 2 - Medium; 1 - Low

OPEN ELECTIVES (OE) – 2/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEOE15	**Waste to Energy Conversion Techniques**	CO1	2		2	3	3	2	3	2			2	2		
		CO2	3	3	1		3						2	2		
		CO3						3					3	3		
		CO4	2	2	3				3	3						
		CO5		3		3						2	2	2		
MEOE16	**Non-Destructive Testing**	CO1	3	3	2	2	1			1		2	2	3		
		CO2	3	3	2	3	3	2		1		1	2	2		
		CO3	3	3	3	3	3	2	2	2	2	2	3	2		
		CO4	2	2	2	3	3	1	1	1	1	1	2	2		
		CO5	3	3	3	3	3	1	1	1	1	3	3	2		
MEOE17	**Pollution and Control**	CO1		3			3	3	3	1		3	2	2		
		CO2	1	3	3	3		3	3	1		1	1	1		
		CO3	3	3	3	2	2	3	3	3	3	2	2	2		
		CO4	3	3	3	2	2	3	3	3	3	2	2	2		
		CO5		3			3	3	3	1		3	2	2		
MEOE18	**Welding Technology**	CO1		3			3	3	3	1		3	2	2		
		CO2	1	3	3	3		3	3	1		1	1	1		
		CO3	3	3	3	2	2	3	3	3	3	2	2	2		
		CO4	3	3	3	2	2	3	3	3	3	2	2	2		
		CO5		3			3	3	3	1		3	2	2		
MEOE19	**Finite Element Method for Engineers**	CO1	3	3			3							3		
		CO2	3	3	1		3							3		
		CO3	3	3	1		3							3		
		CO4	3	3	1		3							3		
		CO5	3	3	1		3							3		

3 - High; 2 - Medium; 1 - Low

OPEN ELECTIVES (OE) – 3/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEOE20	**Computational Methods in Engineering**	CO1	3				3						2	3		
		CO2	3				3						2	3		
		CO3	3				3						2	3		
		CO4	3				3						2	3		
		CO5	3				3						2	3		
MEOE21	**Elementary Continuum Mechanics**	CO1	3	3	1		2	2		2		3	3	3	3	2
		CO2	3	3	1		2	2		2		3	3	3	3	2
		CO3	3	3	1		2	2		2		3	3	3	3	2
		CO4	3	2	2		3	2		2		3	3	3	3	3
		CO5	3	3	1		2	2		2		3	3	3	3	3
MEOE22	**Modern Automotive Technology**	CO1	3	1	2	3	3	1	1			2	2	2		
		CO2	3	3	3	1	1	1	1	1		1	3	3		
		CO3	2	2	2	2	2	1	2	1		2	2	2		
		CO4	2	2	3	1	3	3	3	1	1	1	1	1		
		CO5	3	3	3	2	2	1	2	2	2	2	2	2		
MEOE23	**Hydrogen - Production Handling and Storage**	CO1	3	3	1		2	3	3	2		2	3	1	3	2
		CO2	3	3	1		2	3	3	2		2	2	2	3	3
		CO3	3	2	3		2	3	3	1		2	3	2	3	3
		CO4	3	2	2		2	3	3	1		2	2	3	3	3
		CO5	2	1	3		3	3	3	2		2	3	3	3	3
MEOE24	**Engineering Product Realization**	CO1	3	2	1									2	2	
		CO2	2	3	3		1				2	2		2	3	1
		CO3	3	2	3		2					1	3	2	3	2
		CO4	2	3	2	3	2					1		2	2	3
		CO5	2	2	2			2	2	2	1	2	3	2	2	2

3 - High; 2 - Medium; 1 - Low

ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR) – 1/2

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MELR11	**Manufacturing Technology Laboratory**	CO1	2		2	3		2		2	1	2	1	1	3	3
		CO2	2		2	3		2		2	1	2	1	1	3	3
		CO3	2		2	3		2		2	1	2	1	1	3	3
		CO4	2		2	3		2		2	1	2	1	1	3	3
		CO5	2		2	3		2		2	1	2	1	1	3	3
MELR12	**Computer Aided Design Lab**	CO1	2	1	3		3			2		2		1	3	2
		CO2	2	2	3		3							1	3	1
		CO3	2	2	3	1	3	1	1		2	2	2	1	3	1
		CO4	2	3	3	2	3	1	1		2	2	2	2	3	1
		CO5	2	2	3	3	3	1	2		2	2	2	3	3	1
MELR13	**Thermal Engineering Laboratory**	CO1	3	3	2	3	1				2	2	1	3	3	2
		CO2	3	3	3	3	1				1	3	2	3	3	2
		CO3	3	3	1	3	1				2	2	1	3	3	2
		CO4	3	2	1	3	2				2	3	2	3	3	3
		CO5	3	2	2	2	2				2	3	2	2	3	2
MELR14	**Strength of Materials and Fluid Mechanics Laboratory**	CO1	3	3	2	3	3	2			3	2		3	3	
		CO2	3	3	2	3	3	2			3	2		3	3	
		CO3	3	3	2	3	3	2			3	2		3	3	
		CO4	3	3	2	3	3	2			3	2		3	3	
		CO5	3	3	2	3	3	2			3	2		3	3	
MELR15	**Heat Transfer and RAC Laboratory**	CO1	3	3		3			3		1		1		2	1
		CO2	2	2		3							2		2	1
		CO3	2			3									2	1
		CO4	3	1		3							2		2	1
		CO5	2	2	2								2	1	1	

ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR) – 2/2

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MELR16	**Metrology and Measurements Laboratory**	CO1	3	3	2			1	3	2	1		3		3	1
		CO2	3		2		3		1	1	1	3	3		2	
		CO3	3	3	3		1		1	2			3	1	3	1
		CO4		3			3	3	3		2	2	1	1		2
		CO5	1	1	3		1	3			3	1	3	1		1
MELR17	**Dynamics Laboratory**	CO1	3	3	3	3	3			3	3	3		3		
		CO2	3	3	3	3	3			3	3	3		3		
		CO3	3	3	3	3	3			3	3	3		3		
		CO4														
		CO5														
MELR18	**Automobile Engineering Laboratory**	CO1	3	1	2	3	3	1	1			2	2	2	2	2
		CO2	3	3	3	1	1	1	1	1		1	3	3	3	
		CO3	2	2	2	2	2	1	2	1		2	2	2		
		CO4	2	2	3	1	3	3	3	1	1	1	1	1	1	
		CO5	3	3	3	2	2	1	2	2	2	2	2	2		1

3 - High; 2 - Medium; 1 - Low

HONORS (HO) -1/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEHO10	**Advanced Heat Transfer**	CO1	3			2				3		3			2	
		CO2	3	2					1					2	2	1
		CO3	2		2	1						2			2	1
		CO4	2	2					2	2				3	2	1
		CO5	2		3										1	1
MEHO11	**Advanced Fluid Mechanics**	CO1	3	2	1	2	2							2	3	1
		CO2	3	3	2	2	2							2	3	1
		CO3	3	3	2	2	3							2	3	1
		CO4	3	3	2	3	3							2	3	1
		CO5	3	2	1	2	3							2	3	1
MEHO12	**Advanced Engineering Materials**	CO1	3	2	1	2	2							2	3	1
		CO2	3	3	2	2	2							2	3	1
		CO3	3	3	2	2	3							2	3	1
		CO4	3	3	2	3	3							2	3	1
		CO5	3	2	1	2	3							2	3	1
MEHO13	**Design of Heat Exchangers**	CO1	3												2	1
		CO2			2										2	2
		CO3	2												1	
		CO4	3		1										1	1
		CO5	2												2	
MEHO14	**Design and Optimization of Thermal Energy Systems**	CO1	2					2	3			2	3	2		
		CO2		3							2					
		CO3			1		2	2	2	3		1	2	1		
		CO4				3						2				
		CO5					2	1			1		2	1		

3 - High; 2 - Medium; 1 - Low

HONORS (HO) -2/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEHO15	**Fuels Combustion and Emission Control**	CO1														
		CO2														
		CO3														
		CO4														
		CO5														
MEHO16	**Advanced Computational Methods in Engineering**	CO1	3				3						2	3	2	
		CO2	3				3						2	3	2	
		CO3	3				3						2	3	2	
		CO4	3				3						2	3	2	
		CO5	3				3				2		2	3	2	
MEHO17	**Computational Continuum Mechanics**	CO1	3	3	2		3	2	1	1		2	3	3	3	3
		CO2	3	3	2		3	2	1	1		2	3	3	3	3
		CO3	3	3	3		3	2	1	1		2	3	3	3	3
		CO4	3	2	2		2	2	1	1		2	3	2	3	3
		CO5	3	3	2		3	2	1	1		2	3	2	3	3
MEHO18	**Heat Transfer Equipment Design**	CO1		2								1			2	2
		CO2	2		3			1	2			1			3	2
		CO3	3		3										3	2
		CO4	3		3			2	2						3	2
		CO5	3		3			2	2			1			3	2
MEHO19	**Analysis and Design of Pressure Vessels**	CO1														
		CO2														
		CO3														
		CO4														
		CO5														

3 - High; 2 - Medium; 1 - Low

HONORS (HO) - 3/3

Course Code	Course Title	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEHO20	**Design and Analysis of Turbomachines**	CO1		2		1						2				
		CO2	1	2		1						2				
		CO3	1	2		1						2				
		CO4	3	2		2						1				
		CO5	3	2		3						2				
MEHO21	**Boiler Auxiliaries and Performance Evaluation**	CO1														
		CO2														
		CO3														
		CO4														
		CO5														
MEHO22	**Environmental Pollution Control**	CO1														
		CO2														
		CO3														
		CO4														
		CO5														

3 - High; 2 - Medium; 1 - Low

Programme Core (PC) Courses

Sl. No.	Course Code	Course Title	Credits
1.	**MEPC10**	Engineering Mechanics	4
2.	**MEPC11**	Engineering Thermodynamics	4
3.	**MEPC12**	Applied Electrical and Electronics Engineering	4
4.	**MEPC13**	Manufacturing Technology	4
5.	**MEPC14**	Mechanics of Solids	3
6.	**MEPC15**	Fluid Mechanics and Machinery	4
7.	**MEPC16**	Thermal Engineering	4
8.	**MEPC17**	Mechanics of Machines – I	3
9.	**MEPC18**	Engineering Materials	4
10.	**MEPC19**	Heat and Mass Transfer	4
11.	**MEPC20**	Mechanics of Machines – II	4
12.	**MEPC21**	Metrology and Measurements	3
13.	**MEPC22**	Design of Machine Elements	4
14.	**MEPC23**	Automobile Engineering	3
15.	**MEPC24**	Energy Conversion systems	3

Course Code	**:**	MEPC10
Course Title	**:**	**Engineering Mechanics**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	NIL
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To explain the importance of particle and rigid body mechanics in the context of engineering
CLO2	To explain the significance of centroid, center of gravity, and moment of inertia.
CLO3	To introduce the techniques for analyzing structure and frictional force between contacting bodies.
CLO4	To analyze the kinematics of particle and rigid body in rectangular and curved coordinate system
CLO5	To understand the kinetics of particle and rigid body and compute the energy required to establish the motion

Course Content

Particle Statics: Fundamental concepts and principles of mechanics, Vector calculus fundamentals, Concept of free-body diagram. Resolving forces in Cartesian Coordinates, Resultant force on particle – concurrent force system, Equilibrium of particle, Lami’s Theorem, Particle equilibrium in space (3-D).

Rigid Body Statics: Moment of force and couple, Varignon’s theorem, Moment about an axis- vector triple product, non-concurrent forces. Equilibrium of rigid body, various supports, 2-force and 3-force body in equilibrium. Centroids, center of gravity, area moment of inertia, Principal and mass moment of inertia.

Applications: Structures – Two dimensional trusses, method of joints and sections, Frames, Machines. **Friction-** Laws of friction, application of laws of friction, wedge friction, body on inclined planes, screws and bearings, belt friction.

Kinematics: Particle - rectilinear motion of particle: uniform velocity and acceleration, curvilinear motion of particle: tangential and normal, radial and transverse. **Rigid body**: translation, rotation, general plane motion, absolute and relative velocity, instantaneous center of rotation.

Kinetics: **Particle -** Newton’s second law of motion, dynamic equilibrium, conservation of angular momentum, Work-Energy principle, conservative force field, conservation of energy, Impulse-momentum principle, direct and oblique Impact. **Rigid body** – D’ Alembert’s principle, Forces and acceleration, Energy and momentum methods, basic concepts of mechanical vibrations.

References

1.	R.C. Hibbeler, Engineering Mechanics – Statics and Dynamics, Pearson Education India – 11th edition, ISBN: 978-8131726990, 2009.
2.	Ferdinand P Beer, E Russel Johnston, D F Mazurek, P J Cornwell, B P Self, S Sanghi, Vector Mechanics for Engineers – Statics and Dynamics, McGraw Hill Education (India) Private Limited – 12th Edition, ISBN- 978-9353166625, 2019.
3.	J. L. Meriam, L.G. Kraige, J.N. Bolton, Engineering Mechanics STATICS, Wiley, ISBN- 978-8126564033, 2017. [B] J. L. Meriam, L.G. Kraige, J.N. Bolton, Engineering Mechanics DYNAMICS, Wiley, ISBN-978-8126565375, 2018.
4.	Irving H Shames, G. K. Mohana Rao, Engineering Mechanics – Statics and Dynamics, Pearson Education India – 4th Edition, ISBN- 978-8177581232, 2005.
5.	Timoshenko S, and Young D.H, J. V. Rao, S. Patil, Engineering Mechanics, McGraw Hill, ISBN- 978-1259062667, 2015.
6.	Anthony M. Bedford, Wallace Fowler, Engineering Mechanics: Statics, Pearson – 5th edition, ISBN- 9780136140030, 2008. [B] Anthony M. Bedford, Wallace Fowler, Engineering Mechanics: Dynamics, Pearson – 5th edition, ISBN-9780136140320, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To be able to draw free body diagram and identify unknown reactions at supports
CO2	To be able to locate the center of gravity and mass center of an object and compute the mass and area moment of inertia.
CO3	To effectively utilize the gravitational and frictional forces in mechanical systems
CO4	To compute the linear and angular acceleration of translating and rotating bodies
CO5	To compute the energy required to establish prescribed motion of rigid body

Course Code	**:**	MEPC11
Course Title	**:**	**Engineering Thermodynamics**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	NIL
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn thermodynamic system and familiarize various terminologies associate with the thermodynamic system.
CLO2	To analyse the properties of pure substances, ideal and real gas mixtures
CLO3	To acquire knowledge about the fundamentals of thermodynamic laws, concepts and principles.
CLO4	To predict the availability and irreversibility associated with the thermodynamic processes.
CLO5	To understand the principles of various cycles and to apply the thermodynamic concepts in various applications like IC engines and Air conditioning systems

Course Content

Basic definitions - microscopic and macroscopic approaches, engineering thermodynamic systems. Thermodynamic properties - definition and units, intensive, extensive properties, specific properties. Thermodynamic state - state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic processes. Thermodynamic equilibrium; definition, mechanical equilibrium, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics and the concept of temperature. Measurement of temperature. Thermodynamic definition of work and heat, sign convention. Displacement work - expressions through p-v diagrams. Shaft work; Electrical work. Other types of work.

First law of thermodynamics for non-flow (closed) and flow (open) systems - Steady flow energy equation (SFEE) and applications. Limitations of first law of thermodynamics and introduction to the second law of thermodynamics. Heat engine – concept of efficiency. Concept of refrigerator and heat pump – coefficient of performance. Statements of second law and their equivalence - PMM-I and PMM-II. Carnot cycle.

Concept of reversible and irreversible processes, Causes of irreversibility. Internal and external reversibility. Clausius inequality, Concept of Entropy - principle of increase in entropy, entropy as a quantitative measure of irreversibility. Available (Exergy) and Unavailable energy. Exergy analysis. Irreversibility and second law efficiency.

Pure Substances - P-T and P-V diagrams. Vapor states of pure substance using water as example. Latent heat. Dryness fraction (quality). T-S and H-S diagrams, representation of various processes on these diagrams. Steam tables. Ideal gas mixtures - Dalton's and Amalgam's model. Real gases – Van-der Waal's equation of state. Thermodynamic relations - Partial derivatives - Maxwell relations - Clapeyron equation.

Vapour power cycles - Rankine cycle - Effect of pressure and temperature on Rankine cycle - Reheat cycle - Regenerative cycle. Air standard power cycles - Otto, Diesel, Dual, Stirling and Brayton cycles. Vapour compression refrigeration cycle - Psychometric properties of air - Psychometric chart.

References

1.	Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, 6th ed., John Wiley, 2003.
2.	Cengal, Y.A and Boles, M.A, Thermodynamics: An Engineering Approach, 5th ed., McGraw Hill, 2006.
3.	Nag, P.K., Engineering Thermodynamics, 3rd ed., Tata McGraw-Hill, 2005.
4.	Arora.C.P., “Refrigeration and Air Conditioning”, Tata McGraw Hill, 1994.
5.	Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Define the fundamentals of the first and second laws of thermodynamics and explain
CO2	Analyze the stored and transit forms energies and apply in non-flow and flow systems.
CO3	Classify the fluids and determine their properties by using standard tables and various equations of states
CO4	Evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.
CO5	Analyze various thermodynamic cycles and appreciate the importance of the same to under the working of thermal systems.

Course Code	**:**	MEPC12
Course Title	**:**	**Applied Electrical and Electronics Engineering**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	Basics of Electrical and Electronics Engineering (EEIR11)
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make students analyze the performance of AC motors
CLO2	To make students learn the appropriate motor for different applications in industries
CLO3	To make students learn and analyze combinational logic circuits
CLO4	To make students learn the architecture and instruction set of 8085
CLO5	To make students analyze various control logics for industrial drive applications

Course Content

Three-phase induction motor - Cage and slip ring motors -torque slip characteristics – equivalent circuit - starting and speed control of induction motors – applications.

Single phase induction motors and universal motors- applications. Synchronous motors – principle of operation, starting and applications. Introduction to brushless machines

Electric drive for general factory, textile mill, cement mill - pump, blowers, hoists, traction etc. - group and individual drives. Choice of motors for various applications – drive characteristics and control of drives.

Introduction to operational amplifiers – applications in control circuits. Combinational logic - representation of logic functions – SOP and POS forms K-map representations – minimization using K maps - simplification and implementation of combinational logic – multiplexers and demultiplexers – Introduction to micro- processors and micro-controllers

Control systems – introduction – block diagram reduction – Routh Herwitz criterion-based stability analysis – implementation of control logics to drives.

List of experiments

1. Speed control of three phase induction motor
2. Load test on three phase induction motor
3. Load test on single phase induction motor
4. Realization of integrator and differentiator using operational amplifiers
5. Simulation of performance of three phase induction motor using control blocks

References

1.	Mehta V K and Rohit Mehta, 'Principles of Electrical Machines', S Chand and company Ltd., 2006.
2.	Dubey G K , 'Fundamentals of Electric drives', Narosa book distributors pvt. ltd , 2nd edition, 2012
3.	Ramesh S. Gaonkar, 'Microprocessor Architecture Programming and Applications with 8085', Penram Intl. Publishing, 6th edition, 2013.
4.	Morris Mano, Michael D Ciletti, 'Digital Design', Pearson Education, 4th edition, 2008.
5.	Theraja B L,'A TextBook of Electrical Technology', Vol.2, S Chand,23rd edition,2007.
6.	Vincent Del Toro, 'Electrical Engineering Fundamentals', PHI, 2nd edition, 2009.
7.	Subrahmanyan V, 'Thyristor control of Electric Drives', Tata McGraw Hill, 1st edition.
8.	Nise N.S., *Control Systems Engineering*, Wiley, 2009
9.	Ogata K., *Modern Control Engineering*, Pearson Education, 2015

Course Outcomes (CO)

At the end of the course student will be able

CO1	To analyse the performance of AC motors under various operating conditions using their various characteristics
CO2	To choose appropriate motor for various applications in industries
CO3	To design and analyse combinational logic circuits
CO4	To understand the architecture and instruction set of 8085
CO5	To analyse the various control logics for industrial drive applications

Course Code	:	MEPC13
Course Title	:	**Manufacturing Technology**
Type of Course	:	Programme Core (PC)
Prerequisites	:	NIL
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand material properties, manufacturing processes, and process selection.
CLO2	To learn about various casting and welding methods, their working principles, types, and defects.
CLO3	To learn about various forming processes, such as forging, rolling, drawing, extrusion, and sheet metal forming.
CLO4	To understand various machining processes, including metal cutting, tool geometry, and the economics of machining.
CLO5	To grasp the basic concepts of NC and CNC machine tool programming and rapid prototyping.

Course Content

Introduction to manufacturing process - Selecting manufacturing process – global competitiveness of manufacturing costs – Fundamentals of materials – their behaviour and manufacturing properties – Ferrous metals and alloys – Non-Ferrous metals and alloys.

Casting: Solidification of Alloys and its mechanism – Gating system design and estimation of solidification time – Riser Design and Riser placement – Defects and Product Design. Welding: Physics of Arc sources – Welding equipment - Types of welding processes – Electrode designation and fluxes – Principle and application of Special welding processes. Brazing and Soldering

Forming process: Forging, Rolling, Drawing, Extrusion – Classification, Defects and Inspection. Sheet metal forming process – Shaping process for plastics – Extrusion, Injection and Compression Molding.

Machining process: Various machining process and its working principles – Metal Cutting: Tool geometry – single edge tools – reference plane – Tool specifications – ASA, NRS – Mechanics of Orthogonal cutting and Oblique cutting – Tool wear and Tool life – Economics of Machining

NC & CNC machine tools and manual part programming Machining centre. NC part programming – Computer aided part programming - Rapid Prototyping processes: Stereolithography, Fused Deposition modelling, 3D Printing, Selective laser sintering – Rapid Tooling techniques

References

1.	Callister, W. D., Jr., & Rethwisch, D. G. (2022). *Materials Science and Engineering: An Introduction* (11th ed.). Wiley.
2.	Kalpakjian, S., & Schmid, S. R. (2024). *Manufacturing Engineering and Technology* (11th ed.). Pearson.
3.	Groover, M. P. (2022). *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems* (8th ed.). Wiley.
4.	Rao, P. N. (2018). *Manufacturing Technology: Foundry, Forming, and Welding* (4th ed.). McGraw Hill Education.
5.	Gibson, I., Rosen, D. W., & Stucker, B. (2015). *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing* (2nd ed.). Springer.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand and evaluate the properties of different materials and apply appropriate manufacturing processes based on material characteristics and application requirements
CO2	To demonstrate knowledge of various casting and welding methods, including their working principles, types, and common defects
CO3	To gain proficiency in the principles and applications of forming processes such as forging, rolling, drawing, extrusion, and sheet metal forming
CO4	To acquire a comprehensive understanding of machining processes, including metal cutting, tool geometry, and the economics of machining
CO5	To develop foundational skills in NC and CNC machine tool programming, along with an understanding of rapid prototyping techniques

Course Code	:	MEPC14
Course Title	:	**Mechanics of Solids**
Type of Course	:	Programme Core (PC)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To establish the notion of stress and strain in structural elements, and fundamental relation between material constants.
CLO2	To evaluate the principal stresses and directions using Mohr's circle.
CLO3	To elucidate the shear force, bending moment, deflection and slopes in various types of beams under different loading conditions
CLO4	To understand the design aspects of power transmitting shafts.
CLO5	To impart knowledge on the deflection of springs and buckling of columns

Course Content

Deformation of solid: Introduction-Concept of Stress- Equilibrium of deformable body, area average of normal and shear stress, factor of safety, deformation. **Stress and Strain** - Axial Loading Normal and shear strain, tension test, Hooke's law, Poisson's ratio, volumetric strain, elastic constants. Elastic deformation of axially loaded members, Principle of superposition, statically indeterminate situations of axially loaded member, thermal stresses,

Biaxial loading: **Transformation** of Stress and Strain, Principal stresses and Principal directions, Mohr's circle. **Yielding**: plastic deformation, theories of failure, Tresca and von Mises yield surface, measurement of strain and strain rosettes. **Thin cylindrical** and spherical shells subjected to internal pressure.

Beam bending- Types of beams, different supports and its reactions, Shear force and bending moment diagrams for different loading conditions, Pure bending, Euler-Bernoulli beam theory, shear stress formula, shear center, design of beam based on flexure and shear.

Deflection in beams- Elastic Curve, slopes and displacement by Integration method, Method of Superposition, Moment-Area Method, Energy methods.

Torsion of solid and hollow circular shafts- Deformations in a circular shaft, stresses and angle of twist in elastic range, Torsional formula, Power transmission in shafts, strength and stiffness of shafts. **Deflection of springs**. **Buckling of Columns**- Euler's theory of buckling, critical load for different supports.

References

1.	Beer, F.P, Johnston, E.R., Mechanics of Materials, McGraw-Hill Education -7th edition, ISBN: 9780073398235, 2015.
2.	Hibbeler, R.C., Mechanics of Materials, Pearson Prentice Hall, ISBN- 978-0136022305, 2010.
3.	Gere, M.J., Timoshenko, S.P., Mechanics of Materials, C.B.S., Publishers, 2004. ISBN: 9788123908946
4.	Popov, E.P., Engineering Mechanics of Solids, Pearson,2006. ISBN: 8177585789.
5.	Ramamurtham, S., Strength of Materials, Dhanpat Rai Publications, ISBN: 978-9384378267, 2014.
6.	D Gross, W.Hauger, J. Schroeder, W.A. Wall, J. Bonet, Engineering Mechanics 2 – Mechanics of Materials, Springer-Verlag Berlin Heidelbergr, ISBN 978-3-642-12885-1, 2011.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To analyze and design the structural members subjected to tension, compression, and shear loading
CO2	To draw the Mohr's circle and to determine the principal stresses and its directions.
CO3	To plot the shear force, bending moment variation in beams
CO4	To derive the slope and deflection of beams subjected to lateral loads.
CO5	To understand the torsional effect on shafts, structural stability of slender columns. and defection of springs.

Course Code	**:**	MEPC15
Course Title	**:**	**Fluid Mechanics and Machinery**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	Engineering Mechanics (MEPC10)
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge on mechanics of fluids, types of fluids, various technical parameters of fluids and their relevance to each other and the real applications of fluid mechanics.
CLO2	To formulate and analyze the problems related with immersed and partially immersed bodies in fluids in rest (Fluid Statics) and the instruments that are used for doing fluid flow measurements by applying the law of hydrostatics.
CLO3	To introduce the various types of fluid flow (Fluid Dynamics) and the solution procedures with application of conservation principles for fluid flows.
CLO4	To understand the principles of dimensional analysis and similarity in-line with the model analysis.
CLO5	To analyze design aspects of the fluid machinery and to introduce the methods to study their interaction with the flow medium and loss mechanism of fluid machines.

Course Content

Introduction: Fluids and continuum, Physical properties of fluids, Newton's law of viscosity. Ideal and real fluids, Newtonian and non - Newtonian fluids. Fluid Statics- Pressure -density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure buoyancy, stability of immersed and floating bodies, fluid masses subjected to uniform accelerations, measurement of pressure.

Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows, streamlines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function.

Fluid Dynamics: Euler equation, Bernoulli's equation and its applications, Reynolds transport theorem, conservation of mass, linear and angular momentum, Navier-Stokes equations (without proof), some exact solutions. Pipe Flow: Viscous flow, Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number, shear stress and velocity distribution in a pipe, law of fluid friction, head loss due to friction, Hagen-Poiseuille Equation. Turbulent flow: Darcy-Weisbach equation, Chezy's equation Moody's chart, Major and minor energy losses.

Boundary Layer Theory: Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar and turbulent boundary layers, laminar sub layer, velocity profile, calculation of drag, boundary layer separation.

Fluid Machines: Dimensional analysis and similarity – Raleigh's method, Buckingham Pi theorem, Model Testing and Dimensionless numbers. Types of fluid machines, Euler equation for turbomachines, velocity triangles, centrifugal pumps – cavitation, NPSH, minimum speed requirement. Hydraulic turbines - impulse and reaction turbines, specific speed, unit quantities, governing system, water hammer. Introduction - air compressors, fans and blowers, reciprocating pumps, axial flow pumps.

References

1.	Fox, R.W. and Mc Donald, A.T., Introduction to Fluid Mechanics, 10th ed., John Wiley, 2019.
2.	White, F.M., Fluid Mechanics, McGraw-Hill, 2022.
3.	Yungus A. Cengel, John Cimbala, Fluid Mechanics Fundamental and applications, 3rd ed. Tata McGraw-Hill Education.
4.	John F Douglas, Janusz M Gasiorek, John A Swaffield, Fynne B Jack, Fluid Mechanics, Pearson, 2010.
5.	S. K. Som, Gautam Biswas, Suman Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, 3rd ed. Tata McGraw-Hill Education..
6.	Ojha, C. S. P., Berndtsson R., Chandramouli P. N., Fluid Mechanics and Machinery, Oxford University Press, 2010.
7.	Vijay Gupta, Santosh K Gupta, Fluid Mechanics and its Applications, New Age International, 2015.
8.	K. L. Kumar, Engineering Fluid Mechanics, S. Chand & Company, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Calculate pressure forces on the immersed surfaces and buoyancy force and the variations in accelerating fluids using Euler's and Bernoulli's equations.
CO2	Become conversant with the concepts of flow measurements and flow through pipes.
CO3	Apply the momentum and energy equations to fluid flow problems and they will be in a position evaluate head loss in simple and complex piping systems.
CO4	Use dimensional analysis to design physical or numerical experiments and to apply dynamic similarity.
CO5	Analyze flow and performance of fluid machines with help of velocity components and by formulating the velocity triangles and solving Euler's equation of turbomachines.

Course Code	:	MEPC16
Course Title	:	**Thermal Engineering**
Type of Course	:	Programme Core (PC)
Prerequisites	:	Engineering Thermodynamics (MEPC11)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles, working, and performance of internal combustion (IC) engines.
CLO2	To learn the working principles of compressors, steam nozzles, and various refrigeration and air-conditioning systems.
CLO3	To comprehend the principles of waste heat recovery and thermal storage systems.
CLO4	To analyze the thermodynamic cycles and their applications in real-world systems.
CLO5	To evaluate the performance characteristics and efficiencies of thermal systems.

Course Content

Classification of IC engines – Working of SI & CI, two and four stroke engines – Ideal and actual valve and port timing diagrams – Comparison of ideal and actual air standard cycles (p-v diagram) – Engine operating characteristics: mean effective pressure, torque and power, specific fuel consumption, efficiencies, pressure-crank angle diagram – Determination of fuel properties – Thermochemistry of fuels – Calculation of air fuel ratio – stochiometric, lean and rich mixtures – Exhaust gas analysis

Subcritical and supercritical boilers, fluidized bed boilers, fire-tube and water-tube boilers, mountings and accessories - Steam turbine basic cycles – velocity diagrams, Work done and efficiency – Multistage turbines, governing systems, Effects of reheating and regeneration, Application of Mollier diagram, Gas turbine basic cycle (open and closed), Application of intercooling, reheating and regeneration – cogeneration and combined system

Steam Nozzles: Types and Shapes of nozzles – Flow through nozzles – Stagnation, sonic properties and isentropic expansion in nozzle – Critical pressure ratio – Effect of friction. Metastable flow.

Compressors: Classification of compressors – Radial and axial compressors – Performance characteristics: Volumetric efficiency, Isothermal efficiency and Isentropic efficiency – Effect of clearance volume – Multistage air compressor with intercooling – Surging and stalling, Slip

Refrigeration & air conditioning system: Vapour compression system – Effect of Super heat and Subcooling – Performance calculations - Vapour absorption system - Ammonia water, Lithium bromide water – Psychrometric processes – Air conditioning system – Working principles and concept of RSHF, GSHF, ESHF- Cooling load calculations.

References

1.	Moran, M.J., Moran, H. N. Shapiro, D.D. Boettner, and M.B. Bailey, "Fundamentals of engineering thermodynamics". John Wiley & Sons, 2010.
2.	John Heywood, Internal Combustion Engine Fundamentals, 2nd edition, McGraw Hill, 2018.
3.	P.K. Nag, Basic and Applied Thermodynamics – 2nd Edition, 3rd edition, Tata McGraw-Hill, 2017.
4.	Arora.C.P., "Refrigeration and Air Conditioning", Tata McGraw Hill, 1994.
5.	P. K. Nag, Power Plant Engineering, Tata McGraw-Hill Education Private Limited, Third Edition, New Delhi, 2008
6.	T. D. Eastop and A. McConkey, Applied Thermodynamics for Engineering Technologists, 5th Edition, Pearson, 2003.
7.	Anand Ramanathan, Babu Dharmalingam, Vinoth Thangarasu, "Advances in Clean Energy Production and Application", Taylor & Francis, CRC Press, 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Solve problems related to internal combustion engines and prepare heat balance sheets.
CO2	Explain the components and principles of engines, boilers, compressors, and steam nozzles.
CO3	Design refrigeration and air-conditioning systems for specific applications.
CO4	Demonstrate knowledge of waste heat recovery and thermal storage systems.
CO5	Analyse and evaluate the performance of various thermal systems and cycles.

Course Code	:	MEPC17
Course Title	:	**Mechanics of Machines - I**
Type of Course	:	Programme Core (PC)
Prerequisites	:	Engineering Mechanics (MEPC10)
Contact Hours	:	
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on various types of Mechanisms and its generalization
CLO2	To understand kinematic diagram of mechanism and perform synthesis
CLO3	To impart skills to do position analysis
CLO4	To impart skills to analyze velocity and acceleration of linkages in mechanisms
CLO5	To familiarize higher pairs like cams and gears

Course Content

Kinematics Fundamentals: Types of links, Degrees of freedom - Kinematic chains, mechanisms, Machines - lower pairs and higher pairs - Mobility-Number Synthesis – isomers -Linkage Transformation – inversions - Grashof conditions - Barker's classification - Rotatability and revolvability of N bar Linkages - Compliant Mechanism-MEMS

Graphical Linkage Synthesis: Two position synthesis, rocker output coupler output - three position synthesis - quick return mechanism - coupler curves-symmetrical 4-bar linkage –cognates - introduction to synthesis using coupler curve atlas-limiting conditions, toggle position and transmission angle. Introduction to animation software: Working model

Position analysis: translation rotation and complex motion - Euler's theorem and Chasles' theorem - graphical position analysis - algebraic position analysis - vector loop equation for four bar linkages - circuits and branches in linkages

Velocity analysis: definition of velocity - graphical velocity analysis - instant centers of velocity - Kennedy's rule - velocity analysis using instant centers - mechanical advantage-centrodes - analytical velocity analysis of a 4 bar linkage
Acceleration analysis: definition of acceleration-graphical acceleration analysis - analytical acceleration Analysis - Coriolis acceleration-human tolerance to acceleration

Cams: types of cams and followers-types of motion program-pressure angle and radius of curvature
Gears: fundamental law of gearing - involute tooth form-pressure angle – changing center distance-interference and under cutting- contact ratio - types of gears-simple gear trains - compound gear trains - epicyclic gear Trains - Ferguson's paradox

References

1.	Robert L. Norton.,"Design of Machinery: an introduction to synthesis and analysis of mechanisms and machines", McGraw-Hill Education, ISBN - 978-9351340201, 2017.
2.	Uicker,J.J., Jr., Pennock,G.R., and Shigley, J.E., Theory of Machines and Mechanisms ,3rd ed., Oxford University Press – 4th Edition, ISBN-978-0199454167, 2014.
3.	Kenneth J Waldron, Gary L Kinzel, Kinematics, Dynamics and Design of Machinery, Wiley India Pvt Ltd – 2nd Edition, ISBN – 978 – 8126512553, 2007.
4.	David H Myszka, Machines & Mechanisms: Applied Kinematic Analysis, Pearson – 4th Edition, ISBN-13: 978-0132157803, 2010.
5.	Amitabha Ghosh, Asok Kumar Mallik, Theory of Mechanisms and Machines, East-West Press – 3rd Edition, ISBN – 978-8185938936, 1988.
6.	S.S. Rattan, Theory of Machines, McGraw Hill -5th Edition, ISBN – 978-9353166281, 2019.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To perceive the importance of motion transformation involved in various mechanisms and able to make classifications
CO2	Gain the knowledge of synthesis methods and use software for mechanism animation
CO3	To precisely perform position analysis of linkages in mechanisms
CO4	To quantify the velocity and acceleration at required regions in a mechanism
CO5	Able to analyze the cams and gears and initiate design steps

Course Code	:	MEPC18
Course Title	:	**Engineering Materials**
Type of Course	:	Programme Core (PC)
Prerequisites	:	NIL
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on the atomic arrangement and structure of materials
CLO2	To acquire sound knowledge on phase diagram and heat treatment of materials.
CLO3	To understand the influence of material processing on the material properties
CLO4	To deepen the knowledge about stress-strain curves and metal plasticity
CLO5	To understand the various material testing methods and related failures.

Course Content

Materials Fundamentals: material classification, atomic structure, atomic bonding in solids, crystal structure, crystal systems, crystallographic directions, Miller-Bravais scheme, crystallographic planes, Polycrystalline Materials. Imperfections: point defects, dislocations, Burger vector, grain size, microscopic techniques.

Phase Diagrams: Solubility Limit, phases, microstructures, Gibbs phase rule, Equilibria, binary phase diagram, eutectic, eutectoid, peritectic reactions, Iron- Carbon phase diagram. Phase transformations in metals, kinetics of phase transformations, metastable, equilibrium states, Isothermal transformation (TTT) diagrams, CCT diagram, mechanical behavior of Iron-Carbon alloys.

Material Processing: Ferrous Alloys - classifications, Nonferrous Alloys - copper and aluminum alloys, forming, casting, Heat treatments: Annealing, Precipitation hardening, austempering, martempering, surface hardening, hardenability.

Testing: Concepts of stress-strain, elastic properties, tensile properties, true stress-strain, elastic recovery and plastic deformation, hardness. Dislocations and Strengthening Mechanisms: Characteristics of dislocation, slip systems and slip in single crystal. plastic deformation in polycrystalline materials, twinning, strengthening by grain size reduction, strain hardening, recovery, recrystallization, grain growth.

Failure: Fracture - Fundamentals of Fracture, Ductile and brittle fracture, Impact Fracture Testing. Fatigue – Cyclic stress, S-N curve, crack initiation and propagation, fatigue life and improvement methods, Creep behavior, stress and temperature effects, alloys for high temperature.

Laboratory Experiments:

Metallography specimen preparation, Optical microscopy (microstructure evaluation of cast iron, carbon steel. stainless steel and alloy steels), Mechanical Characterization of materials- Tensile testing, Impact testing and Hardness testing, heat treatment of steels – annealing, normalizing, and quenching microstructure comparison.

References

1.	Sidney H Avner, Introduction to Physical Metallurgy, McGraw Hill Education – 2nd edition, ISBN- 978-0074630068, 2017.
2.	George E Dieter, Mechanical Metallurgy, McGraw Hill Education – 3rd edition, ISBN- 978-1259064791, 2017.
3.	William D. Callister JR, David G. Rethwisch, Materials Science and Engineering - An Introduction, 10th edition, John Wiley & Sons, 2018.
4.	R. Balasubramaniam, Callister's Materials Science and Engineering, Wiley – 2nd edition, ISBN - 978-8126541607, 2014.
5.	William F Smith, Javad Hashemi, Ravi Prakash, Material Science and Engineering, McGraw Hill Education- 5th edition, ISBN-978-1259062759, 2017.
6.	A.V.K. Suriyanarayana, Testing of metallic materials, BS Publications, ISBN-978-8178001340, 2007.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To Interpret the atomic arrangement and structure of materials.
CO2	To describe the iron-carbon equilibrium diagram and phase diagrams.
CO3	To explain the behavior of material upon heat treatment from iron-carbon equilibrium diagram
CO4	To interpret the uniaxial tension test and ductility of various materials
CO5	To predict the behavior of materials upon impact, fracture and creep testing

Course Code	:	MEPC19
Course Title	:	**Heat and Mass Transfer**
Type of Course	:	Programme Core (PC)
Prerequisites	:	Transforms and Partial Differential Equations (MAIR32) Engineering Thermodynamics (MEPC11) Fluid Mechanics and Machinery (MEPC15)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify the important and /or possible heat transfer modes in any physical system
CLO2	To provide students an opportunity of direct experience of doing heat transfer calculations so that they can understand the basic principles and able to make a critical assessment of industrial environment.
CLO3	To experience with practical applications of heat transfer
CLO4	To apply the energy balance equation to heat transfer problems to calculate the rate of heat transfer for all physical devices in all modes of heat transfer
CLO5	To Understand the concept of mass transfer and its similarities with heat transfer

Course Content

Conduction - general 3-D equation – one dimensional steady state heat conduction in simple geometries – plane wall – cylinder and sphere – composite walls – critical thickness of insulation – thermal contact resistance - heat generation in plane wall, cylinder and sphere – extended surfaces - unsteady state heat conduction.

Convection - boundary layer theory – conservation equations of mass, momentum and energy for laminar flow over a flat plate – turbulent flow over a flat plate – flow over cylinders – spheres – bank of tubes - internal flows – natural convection – vertical, inclined and horizontal surfaces.

Radiation heat transfer – thermal radiation – laws of radiation - Black and Gray bodies – shape factor-radiation exchange between surfaces - Radiation shields - Greenhouse effect.

Boiling and condensation – pool boiling regimes and correlations – critical heat flux - flow boiling correlations - Nusselt's theory – filmwise and dropwise condensation - Condensation over surfaces.

Heat exchangers - types - fouling factor - LMTD and NTU methods - Mass transfer - Fick's law - analogy between heat and mass transfer

References

1.	Bergman T.L., Lavine A.S., Incropera F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley & Sons, 2012.
2.	Holman, J.P., Heat Transfer, 10th ed., Tata McGraw-Hill, 2010.
3.	Ozisik, M.N., Heat Transfer - A Basic Approach, McGraw-Hill, 1985.
4.	Cengel, Y.A., Heat Transfer - A Practical Approach, 2nd ed., McGraw-Hill, 2002.
5.	Nag P.K., Heat and Mass Transfer, 3rd ed., McGraw-Hill Education, 2011
6.	Data Book - Heat & Mass Transfer – Kothandaraman C.P., Subramanyan S, New Age International Publishers
7.	Eckehard Specht, Heat and Mass Transfer in Thermoprocessing: Fundamentals, Calculations, Processes, Vulkan Verlag, 2017. ISBN: 9783802729911.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Analyze the real time applications of conduction heat transfer in solids.
CO2	Describe the fundamentals of natural and forced convective heat transfer processes.
CO3	Explore the real time applications of radiation mode of heat transfer
CO4	Design the heat exchange equipment.
CO5	Relate the mass transfer concepts for various industrial applications.

Course Code	**:**	MEPC20
Course Title	**:**	**Mechanics of Machines - II**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	Mechanics of Machines – I (MEPC17)
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To establish strong foundation in kinetics of mechanisms
CLO2	To familiarize balancing methods for rotating and reciprocating masses
CLO3	To introduce gyroscope and flywheels
CLO4	To familiarize fundamentals of vibrations in machineries
CLO5	To understand vibration control

Course Content

Fundamentals of dynamics: center of mass, mass moment of inertia, principle of virtual work. Static and inertial force analysis of mechanisms: Newtonian method, four-bar linkage, slider crank, shaking force and moment.

Balancing: rotating masses in single and several planes- reciprocating masses- single and multi-cylinder engines-Lanchester balancer

Flywheel: industrial uses of flywheels- design of a flywheel of IC engines and punch press. **Gyroscopes**: rigid body motion in 3D, Euler's equation, symmetrical rotor, Gyrodynamics, Effect of Gyroscope in ship and flights.

Mechanical vibrations: Introduction to vibration, Types of vibration, single DoF system, Free vibration of rigid bodies, linear and torsional vibrations- two rotor, three rotors and multi rotor systems- damped vibrations, types of damping - coupled vibrations - forced vibrations - vibration sensors.

Vibration control: philosophy of vibration control-vibration isolations- suspension systems-tuned vibration absorbers- uses of vibration in condition monitoring.

References

1.	Robert L. Norton., "Design of Machinery: an introduction to synthesis and analysis of mechanisms and machines", McGraw-Hill Education, ISBN - 978-9351340201, 2017.
2.	George H. Martin., "Kinematics and Dynamics of Machines" 2nd ed., Waveland PrInc., 2002.
3.	Morrison. J.L.M., Crossland.B., "An Introduction to the Mechanics of Machines" 1st ed., Longman Higher Education Division (a Pearson Education company), ISBN – 978- 0582447295, 1971.
4.	Daniel J. Inman, Engineering Vibrations, Pearson Education – 4th Edition, ISBN - 978-0132871693, 2013.
5.	Uicker, J.J., Jr., Pennock, G.R., and Shigley, J.E., Theory of Machines and Mechanisms ,3rd ed., Oxford University Press – 4th Edition, ISBN-978-0199454167, 2014.
6.	Kenneth J Waldron, Gary L Kinzel, Kinematics, Dynamics and Design of Machinery, Wiley India Pvt Ltd – 2nd Edition, ISBN – 978 – 8126512553, 2007.
7.	David H Myszka, Machines & Mechanisms: Applied Kinematic Analysis, Pearson – 4th Edition, ISBN-978-0132157803, 2010.
8.	Amitabha Ghosh, Asok Kumar Mallik, Theory of Mechanisms and Machines, East-West Press – 3rd Edition, ISBN – 978-8185938936, 1988.
9.	S.S. Rattan, Theory of Machines, McGraw Hill -5th Edition, ISBN – 978-9353166281, 2019.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To perform static and dynamic analysis of mechanisms
CO2	To understand the issues related to balancing of reciprocating and rotating machinery
CO3	To know the working of gyroscopes and flywheels
CO4	To have understanding about the types of vibration
CO5	To appreciate the vibration controlling methods

Course Code	:	MEPC21
Course Title	:	**Metrology and Measurement**
Type of Course	:	Programme Core (PC)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Describe the evolution of quality standards and metrology.
CLO2	Provide knowledge of limits, fits, tolerances, and gauging.
CLO3	Introduce measurement systems and methods emphasizing different transducers, intermediate modifying, and terminating devices.
CLO4	Measure Surface Texture and Dimensional Features
CLO5	Apply Measurement Principles in Instrumentation Systems

Course Content

Introduction to Metrology- Introduction to Metrology, fundamental principles and definitions, measurement standards / primary and tertiary standards, and the distinction between precision and accuracy. Limits fit and tolerances, Tolerance grades, Types of fits, IS919, GO, and NO-GO gauges- Taylor's principle, design of GO- and NO-GO gauges, filler gauges, plug gauges, and snap gauges.

Comparators - Constructional features and operation of mechanical, optical, electrical/electronic, and pneumatic comparators, advantages, limitations, and field of applications. Principles of interference, concept of flatness, flatness testing, optical flats, optical interferometer, and laser interferometer. Surface Texture Measurement - importance of surface conditions, roughness, and waviness, surface roughness standards specifying surface roughness parameters- Ra, Ry, Rz, RMS value, etc., surface roughness measuring instruments – Tomlinson and Taylor Hobson versions, surface roughness symbols.

Screw Thread Measurement - Two-wire and three-wire methods, floating carriage micrometer. Gear Measurement - Gear tooth comparator, Master gears, measurement using rollers, and Parkinson's Tester. Special Measuring Equipment - Principles of measurement using Tool Maker's microscope profile projector & 3D coordinate measuring machine

Generalized instrumentation system – Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity – Signal conditioning systems. Error analysis – Uncertainty propagation – Oscilloscope for analysis of dynamic and transient events.

Principles and analysis of measurement systems used to measure flow, power, pressure, and temperature.

References

1.	Mechanical Measurements, Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2019.
2.	Measurement Systems, Ernest O Doeblin, Mc Graw-Hill, 2004.
3.	Measurement and Instrumentation: Theory and Application, Alan S Morris, Reza Langari, Elsevier, India, 2013.
4.	Engineering Metrology, Jain R K, Khanna publishers, New Delhi,2015.
5.	Fundamentals of dimensional metrology, Connie L Dotson, Cengage learning, Chennai, 2019.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate different measurement techniques.
CO2	Reproduce the fundamental knowledge on metrology techniques.
CO3	Identify suitable metrological methods for measuring the components.
CO4	Explain the acceptance test for machines.
CO5	Outline the working of various optical measuring instruments.

Course Code	:	MEPC22
Course Title	:	**Design of Machine Elements**
Type of Course	:	Programme Core (PC)
Prerequisites	:	Mechanics of Solids (MEPC14) Mechanics of Machines – I (MEPC17)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize machine component failure under various loadings
CLO2	To develop the basic notion of steps involved in the design of shaft and couplings
CLO3	To analyze the functional and strength requirements of various mechanical joints and bearings.
CLO4	To learn to use catalogues and standard involved in machine components design
CLO5	To understand the factors involved in gear, spring, and belt design

Course Content

Introduction to Design: Design process - Problem formulation and calculation – Factor of safety – Design codes. Materials and process, Loading determination – Static loading, Dynamic loading, Impact loading. Displacement, Stress, Strain, Principal stresses, Types of stresses. Design of simple machine parts.

Failure Theories – failure theories of ductile and brittle materials under static loading, Fatigue failure theories: Mechanism, Models, Notches and stress concentration.

Design of Shafts, Keys and Couplings – Static loads, combined torsion-Bending and axial loads, Critical speed of the shaft. Design of keys and Keyways, Failure of keys. Couplings – Rigid and Flexible types.

Lubrications and Bearings: Lubricants – Properties – Types. Bearings – Sliding contact, rolling contact bearings – Hydrodynamic Bearing.

Design of springs: Helical compression springs – Terminologies, Static and Fatigue loading. Leaf Springs.

Design of Welding and Fastening: Joints subjected to axial and eccentric loads.

Design of Flexible mechanical elements – Belt, Chain and Rope.

Design of Gears – Gear Terminologies, Types of gears, Materials for gears, Design of Spur Gear, Helical Gear, Bevel gears, Worm and Worm Gear
Design of single stage and multistage Gear boxes.

References

1.	Joseph Edward Shigley, Mechanical Engineering Design, McGraw-Hill, Tenth Edition in SI units, 2017.
2.	Robert L. Norton, Machine Design, Pearson Paperback, 2018.
3.	Robert C. Juvinall and Kurt M. Marshek, Machine Component Design, Wiley Publishers, 2016.
4.	V.B. Bhandari, Design of Machine Elements Paperback, McGraw Hill, 2017
5.	Linda C. Schmidt, George Dieter, Engineering Design, McGraw Hill, 2017
6.	Design Data: Data Book of Engineers by PSG College-Kalaikathir Achchaga, Coimbatore, 2012.
7.	Sundararajamoorthy, T.V. and Shanmugam, N., Machine Design, Anuradha Agencies, ISBN: 81-87721-20-0, 2003
8.	George E Dieter, Linda C. Schmidt, Engineering Design, McGraw Hill Education India Pvt Ltd, Fourth edition, ISBN: 978-1259064852, 2017.
9.	Richard G Budynas, J Keith Nisbett, Mechanical Engineering Design, 10th ed., McGraw-Hill, ISBN: 978-9339221638, 2017.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To describe the design process, material selection, stress concentrations under various loading.
CO2	To understand the limits and constrains imposed by the material in terms of failure
CO3	To design machine elements like shaft, couplings, bearings and springs.
CO4	To recognize the need and procedure to design flexible and positive drives.
CO5	To apply catalogues and standards in machine component design.

Course Code	**:**	MEPC23
Course Title	**:**	**Automobile Engineering**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the automobile structure, comfort and safety systems.
CLO2	To impart knowledge on IC engine, electric and hybrid vehicles.
CLO3	To understand the manual and automatic transmission systems.
CLO4	To understand vehicle running and control systems.
CLO5	To analyze electrical and electronics system for vehicle management.

Course Content

Vehicle Structure, Comfort and Safety

Automobiles - layouts, chassis, frame, body – material and construction. Aerodynamics - Flow phenomenon - drag, side and lift force, rolling resistance. Ergonomics and anthropometry - comfort systems - Air conditioning - Noise, Vibrations and Harshness. Vehicle safety systems - Regulations and test standards.

Engine and Auxiliary Systems

SI and CI Engines – principle of operation. Air and Fuel systems - MPFI, GDI & CRDI, Turbochargers. Cooling and Lubrication systems. Typical performance, combustion and emission characteristics of automobile engines. Emission standards and control strategies - recent developments.

Transmission Systems

Manual and automatic transmission system – clutch, gear box, over drives, transfer box, fluid flywheel, torque convertors, Continuously Variable Transmission (CVT). Propeller shaft - hotchkiss drives, torque tube drive, universal joints. Final drive - differential - rear axle.

Steering, Brakes and Suspension Systems

Axle - Wheel geometry - Wheel alignment and balancing - Steering geometry - Power steering. Hydraulic and pneumatic braking systems - factors affecting braking - Antilock Braking System (ABS). Suspension - types, factors influencing ride comfort. Tyres – types, static and rolling properties, tyre wear and maintenance.

Automotive Electrical and Electronics

Wiring harness. Starting & Ignition system. Automotive lighting. Automotive sensors & actuators, Engine & Vehicle Management System. Fundamentals of electric and hybrid vehicles - Power train - Regenerative braking - Electric charging – Battery Thermal Management System (BTMS) - Autonomous Vehicles.

References

1.	Newton, K., Steeds, W., and Garrett, T.K., The Motor Vehicle, Butterworth, 1989.
2.	Joseph Heitner, “Automotive Mechanics”, 2nd edition, East-West Press, 1999.
3.	Heinz Heisler,”advanced Engine technology “SAE international publications USA, 1998.
4.	Kirpal Singh, Automotive Engineering, Vol. I & II, Standard Publishers, New Delhi, 1997
5.	George A. Peters and Barbara J. Peters, Automotive Vehicle Safety, Tailor and Francis, CRC Press, 2002.
6.	Mark Gonter, Ulrich W. Seiffert, Integrated Automotive Safety Handbook, SAE International, 2013.
7.	Tom Denton, Automobile Electrical & Electronic Systems (5th Edition), Taylor and Francis, 2018.
8.	Chris Mi, M. Abul Masrur, Electric Vehicles, 2nd Edition, Wiley, 2018.
9.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, 3rd Edition, CRC Press, 2018.
10.	George Dimitrakopoulos, Aggelos Tsakanikas, Elias Panagiotopoulos, Autonomous Vehicles: Technologies, Regulations, and Societal Impacts, 1st Edition, Elsevier, 2021.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the automobile structure, comfort and safety systems.
CO2	To understand the principles of IC engine, electric and hybrid vehicles.
CO3	To understand the manual and automatic transmission systems.
CO4	To understand vehicle running and control systems.
CO5	To understand electrical and electronics system for vehicle management.

Course Code	**:**	MEPC24
Course Title	**:**	**Energy Conversion systems**
Type of Course	**:**	Programme Core (PC)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Analyze the thermodynamic cycles used in power generation
CLO2	Evaluate the merits of direct thermal energy conversion systems compared to conventional techniques
CLO3	Analyze the performance of fuel cells
CLO4	Select the best energy storage mechanism for any given application
CLO5	Developing a mechanism for total energy recovery from a system adopting CHCP concept

Course Content

Energy Conversion Cycles: Bell Coleman, Scuderi, Stirling, Ericsson, Lenoir, Atkinson, Stoddard and Kalina cycle – Comparison with Rankine and Brayton cycles

Direct Conversion of Thermal to Electrical Energy: MHD - Thermoelectric Converters – Thermoelectric refrigerator – Thermoelectric Generator – Thermionic converters – Ferro electric converter – Nernst Effect Generator – Thermo Magnetic Converter.

Direct Conversion of Chemical to Electrical Energy: Fuel Cell: Basics – working advantages and drawbacks – types – comparative analysis – thermodynamics and kinetics of fuel cell process – performance of fuel cell – applications

Energy Storage Systems: Batteries – types – working – performance governing parameters – hydrogen energy – solar cells. Energy storage devices for Mechanical Energy, Electrical Energy, Chemical Energy, Thermal Energy.

Combined Heat and Power Production: Cogeneration - types - Configuration and thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – concept of Polygeneration

References

	Archie.W.Culp, Principles of Energy Conversion, 2ndEdition, McGraw-Hill Inc., 1991, New York.
	Kordesch Karl, and Günter R. Simader, Fuel Cell and Their Applications, Wiley 2006
	Bent Sorensen, Renewable Energy Conversion, Transmission, and Storage Technology & Engineering, Academic Press, 2007.
	Charles R. Russell, Elements of Energy Conversion, Permagon Press, 1967.
	Hart A.B. and Womack, G.J., Fuel Cells: Theory and Application, Prentice Hall, 1989.
	Kettari, M.A., Direct Energy Conversion, Addison-Wesley, 1997.
	Yogi Goswami, D. and Frank Kreith, Energy Conversion, Second Edition, Science, 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze the thermodynamic cycles used in power generation
CO2	Evaluate the merits of direct thermal energy conversion systems compared to conventional techniques
CO3	Analyze the performance of fuel cells
CO4	Select the best energy storage mechanism for any given application
CO5	Develop a mechanism for total energy recovery from a system adopting CHCP concept

Programme Elective (PE) Courses List

S. No	Course Code	Elective Course	Stream
1.	MEPE31	Computer Aided Design and Drafting	Design
2.	MEPE35	Machine Drawing	Design
3.	MEPE36	Introduction to AI & ML for Mechanical Engineering	Design
4.	MEPE32	Industrial Safety Engineering	Industrial
5.	MEPE33	Biofuels	Thermal
6.	MEPE34	Renewable Energy Sources	Thermal
7.	MEPE41	Mechatronics	Industrial
8.	MEPE42	Continuum Mechanics	Design
9.	MEPE43	Advanced IC Engines	Thermal
10.	MEPE44	Additive Manufacturing	Industrial
11.	MEPE45	Industrial Tribology	Industrial
12.	MEPE51	Advanced Mechanics of Solids	Design
13.	MEPE52	Compressible Flow and Jet Propulsion	Thermal
14.	MEPE53	Operations Research	Industrial
15.	MEPE61	Refrigeration and Air Conditioning	Thermal
16.	MEPE62	Computational Fluid Dynamics	Thermal
17.	MEPE63	MEMS Devices – Design and Fabrication	Design
18.	MEPE64	Mechanical Vibrations	Design
19.	MEPE65	Convective Heat Transfer	Thermal
20.	MEPE71	Finite Element Method	Design
21.	MEPE72	Power Plant Engineering	Thermal
22.	MEPE73	Fundamentals of Robotics	Industrial
23.	MEPE74	Cryogenic Engineering	Thermal
24.	MEPE75	Vehicle Dynamics	Design
25.	MEPE76	Fundamentals of Biomechanics	Design
26.	MEPE77	Mechanics of Composite Materials	Design
27.	MEPE78	Advanced Automotive Technology	Industrial
28.	MEPE81	Quality Control	Industrial
29.	MEPE82	Introduction to Fracture Mechanics	Design
30.	MEPE83	Dynamics of Machinery	Design
31.	MEPE84	Fundamentals of HVAC Systems	Thermal
32.	MEPE85	Alternative Refrigerants	Thermal

Programme Elective (PE) Courses – 1/3

Stream I (Thermal Engineering)

Sl. No.	Course Code	Course Title	Credits
1.	MEPE33	Biofuels	3
2.	MEPE34	Renewable Energy Sources	3
3.	MEPE43	Advanced IC Engines	3
4.	MEPE52	Compressible Flow and Jet Propulsion	3
5.	MEPE61	Refrigeration and Air Conditioning	3
6.	MEPE62	Computational Fluid Dynamics	3
7.	MEPE65	Convective Heat Transfer	3
8.	MEPE72	Power Plant Engineering	3
9.	MEPE74	Cryogenic Engineering	3
10.	MEPE84	Fundamentals of HVAC Systems	3
11.	MEPE85	Alternative Refrigerants	3

Course Code	**:**	MEPE33
Course Title	**:**	**Biofuels**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the importance of biofuels and characterize different biomass feedstock based on its constituents and properties.
CLO2	To evaluate various biomass pre-treatment and processing techniques in terms of their applicability for different biomass types.
CLO3	To identify the biofuel production technologies for various applications and compare the conversion technologies.
CLO4	To provide students with the advanced biofuel production techniques and recent research in advancement.
CLO5	To assess the economic and environmental status of biofuels and various biofuel applications.

Course Content

Overview of energy resources - conventional vs. renewable energy sources. Introduction to biomass, biofuels and bioenergy. Biomass sources, constituents and properties. Biomass classification and characterization. Biofuel – importance, classification and production methods. Fuel properties and standards.

Importance of biomass pre-treatment, physical, chemical and biological pre- treatment methods. Combined and novel pre-treatment approaches – steam explosion, Ammonia Fiber Explosion (AFEX), and ionic liquids. Impact of pre- treatment on biofuel production – enhancement of conversion efficiency, yield, and by-products.

Biomass conversion technologies – thermochemical, biochemical and physicochemical methods. Bioethanol and biodiesel production process. Biofuel production from waste materials and waste oil, biogas and bio-hydrogen production process. Algae and microalgae cultivation, harvesting, and oil extraction techniques.

Advances in feedstock development. Synthetic biology, CRISPR in biofuel production, and 4th generation biofuels. Refinement processes, blending, and additive technology for biofuels production. Various advanced biofuel production technologies. Advancements in microbial fermentation of agro and food processing wastes.

Comparative cost analysis of biofuels vs. fossil fuels. Carbon footprint reduction, policy impacts and market potential associated with biofuels. Use of biofuels in vehicles. Combustion of biomass, biogas, and algal biofuels for electricity production. Biofuels in heating, CHP and chemical production.

References

1.	Anju Dahiya, Bioenergy: Biomass to Biofuels, Elsevier, 2015.
2.	Inamuddin, Tariq Altalhi (Ed.), Solid-Gaseous Biofuels Production, 2024.
3.	Carlos Ricardo Soccol, Satinder Kaur Brar, Kugenthiren Permaul, Kannan Pakshirajan, Júlio Cesar de Carvalho, Biohydrogen (Ed.) Advances and Processes, 2024.
4.	Rafael Luque, Carol Sze Ki Lin, Karen Wilson, Chenyu Du (Ed.), Handbook of Biofuels Production, 2022.
5.	Sanjay Sahay, Handbook of Biofuels, 2021.
6.	Sunggyu Lee and Y.T. Shah, Biofuels and Bio-energy Processes and Technology, CRC Press, Taylor and Francis Group, 2013.
7.	Pandey, A., Larroche, C., Ricke, S.C., Dussap, C.-G., Gnansounou, E., Biofuels: Alternative feedstocks and conversion processes, Academic Press, U.S.A., 2011.
8.	Brown, R.C. (Ed.) Thermochemical processing of biomass into fuels, chemicals and power, Wiley, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Know importance of the biofuels over the fossil fuels and understand how to choose the suitable biomass fuels for different bio-energy applications.
CO2	Address the desirable features of biomass pre-treatment and their advantages over the competitive methods.
CO3	Identify suitable biomass conversion technique for different applications and apply the waste to energy techniques to meet sustainable environment.
CO4	Evaluate and apply advanced biofuel production technologies to improve biofuel efficiency and innovation.
CO5	Perform the economic and environmental assessments on biofuels and apply the biofuels for the various applications.

Course Code	**:**	MEPE34
Course Title	**:**	**Renewable Energy Sources**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principle of working and the components of different non-conventional sources of energy
CLO2	To get an exposure to the wind energy, Biomass, geothermal energy, tidal energy, fuel cells and energy conversion technologies.
CLO3	To Understand the basic concepts of the solar radiation and analyse the solar thermal systems for their utilization
CLO4	To Identify the renewable energy sources, their utilization and storage.
CLO5	Explain the energy harvesting methods from various energy sources

Course Content

Solar Energy: Present renewable energy status in India - Solar radiation – Measurements of solar radiation and sunshine – 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.

Wind Energy: Wind data and energy estimation – Betz limit - Site selection for wind farms – Horizontal axis wind turbine – Vertical axis wind turbine – Wind turbine generators and its performance – Hybrid systems – Environmental issues - Applications.

Bio – Energy: Bio resources – Biomass direct combustion – Biomass gasifier - Types of biomass gasifiers - Cogeneration –- Carbonization – Pyrolysis - Biogas plants – Digesters –Biodiesel production – Ethanol production - Applications.

Ocean and Geothermal Energy: Small hydro - Tidal energy – Wave energy – Open and closed OTEC Cycles – Limitations – Geothermal energy – Geothermal energy sources - Types of geothermal power plants – Applications - Environmental impact.

New Energy Sources: Fuel cell – Principle - Types of fuel cells – Hydrogen energy – Properties – Hydrogen production – Storage – Transport and utilisation - Safety issues. Energy Storage methods and devices.

References

1.	G.D. Rai, "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2014.
2.	Twidell, J.W. & Weir, A., "Renewable Energy Resources", EFN Spon Ltd., UK, 2005.
3.	Bent Sorensen, Renewable Energy Conversion, Transmission, and Storage Technology & Engineering, Academic Press, 2007.
4.	Charles R. Russell, Elements of Energy Conversion, Permagon Press, 1967.
5.	Hart A.B. and Womack, G.J., Fuel Cells: Theory and Application, Prentice Hall, 1989.
6.	Kettari, M.A., Direct Energy Conversion, Addison-Wesley, 1997.
7.	B.H. Khan, "Non-Conventional Energy Resources", The McGraw Hill companies, 2009

Course Outcomes

At the end of the course student will be able

CO1	To estimate solar radiation and formulate heat transfer equations and analyze of modern energy conversion technologies
CO2	To describe various renewable energy resources and techniques to utilize them effectively.
CO3	Compute wind energy potential and predict the performance of wind turbines
CO4	Describe and analyze photovoltaic systems
CO5	Distinguish the various form of energies such as magneto hydrodynamic, thermionic and fuel cell.

Course Code	**:**	MEPE43
Course Title	**:**	**Advanced IC Engines**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the combustion phenomena in SI and CI engines.
CLO2	To understand the formation of exhaust gases, control strategies and its measurement techniques.
CLO3	To study the mechanism of different subsystem used in an engine test bed facility
CLO4	To study the recent technologies adopted for improving the engine performance and emission characteristics
CLO5	To apply the advanced imaging techniques used for combustion and spray characterization.

Course Content

SI and CI engines: Mixture requirements – Stages of combustion – Normal and Abnormal combustion, Knock and Pre-ignition – Factors influencing knock – Gasoline and diesel Fuel injection systems Fuel Spray behavior – Spray structure and spray penetration – Air motion: Tumble, Swirl & Squish – Different Combustion chamber geometries – Super charging and Turbo charging

Emission Formation and Control: Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Exhaust Gas Analysis – Methods of controlling emissions – In-cylinder treatments: Injection strategies, Exhaust gas recirculation, Spark Advancement – After treatment systems: Three Way Catalytic converter, SCR, LNT, DOC, DPF and Particulate Traps.

Engine Testing and Measurement Systems: Test cells and dynamometer – Fuel and airflow measurement system – in-cylinder pressure transducers and crank angle encoders – Emission standards and driving cycles – Methods and principles of emission measurement – non-dispersive infrared gas analyzer, chemi-luminescent analyzer, flame ionization detector, smoke meters and soot analyzer

Advanced Combustion concepts: Low Temperature Combustion – Homogeneous charge compression ignition (HCCI) – Reactivity Controlled Compression Ignition (RCCI) – Advanced Ignition system – Gasoline Compression Ignition – Multi-stroke engines – Recent technological developments

Combustion Visualization: Optical Engine, Endoscopic access & optical chambers – In-cylinder flow and species measurements: Particle image velocimetry – Laser Doppler Anemometry – Planar Laser induced Fluorescence – Schlieren and shadowgraphy techniques – Chemi-luminescence Imaging.

References

1.	Heywood, JB., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
2.	Ganesan, V., Internal Combustion Engines, 4th edition, McGraw-Hill, 2017.
3.	R.K. Maurya, Reciprocating Engine Combustion Diagnostics, Springer, 2018.
4.	G. Kalghatgi, Fuel and Engine Interactions, SAE Publications, 2014.
5.	Heinz Heisler, Advanced Engine Technology, SAE Publications, 1995
6.	R.K. Maurya, Characteristics and Control of Low Temperature Combustion Engines, Springer, 2018.
7.	Hua Zhao, Laser Diagnostics and Optical Measurement Techniques in Internal Combustion Engine, SAE Publications, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the combustion phenomena in SI and CI engines.
CO2	Identify the pollutants formation mechanism and measurement techniques.
CO3	Understand the mechanism of different subsystem used in an engine test bed facility
CO4	Explain the advanced combustion concepts used to increase engine efficiency and reduce emission levels
CO5	Illustrate the advanced imaging techniques used for combustion and spray characterization.

Course Code	**:**	MEPE52
Course Title	**:**	**Compressible Flow and Jet Propulsion**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize with the differences between incompressible and compressible flows.
CLO2	To draw the connection between compressible flow and thermodynamics.
CLO3	To provide knowledge on various types of shocks.
CLO4	To impart knowledge on the effect of friction and heat transfer on compressible flows.
CLO5	To impart skills and analyze engines used for jet propulsion

Course Content

Fundamentals: Governing equations for inviscid-compressible flows - static and stagnation properties - speed of sound and Mach number, continuity, momentum and energy equations, mathematical derivations of Bernoulli's equation for incompressible and compressible fluid flows, effects of compressibility on the fluid flow measurements, application incompressible fluid flow standard tables.

Isentropic flows: through variable area passage ducts - Flow through nozzles and diffusers, chocked flow, critical pressure ratio, application of equation of critical pressure ratio, variable cross-sectional area flow.

Flow with shocks: Normal and oblique shocks, causes and effects of shocks, Prandtl-Meyer and Rankin-Hugoniot equation equations.

Flow with effects of friction and heat transfer: Fanno flow, isothermal fluid flow, Rayleigh flow, concepts of maximum length and its variation on subsonic and supersonic fluid entry.

Jet Propulsion: Fundamentals of jet propulsion - Thermodynamic cycle analysis and efficiencies of propulsive devices. Thrust equation, classification and comparison of ram jets, turbojets, pulse jets and rockets. Performance of turbo-prop, turbo-jet and turbo-fan engines. Augmentation of thrust.

References

1.	Yahya, S. M., Fundamentals of Compressible Flow, Pub.: New Age International Publishers
2.	Balachandran, P., Fundamentals of Compressible Fluid Dynamics, Pub. PHI Learning
3.	Radhakrishnan, E., Gas Dynamics, Pub. PHI Learning
4.	Radhakrishnan, E., Applied Gas Dynamics, Pub.: Wiley India
5.	Oosthuizen, P.H. and Carscallen, W.E., Compressible Fluid Flow, Pub.: Mc Graw-Hill Education
6.	Anderson, J. D., Modern Compressible Flow with Historical Perspective, Pub.: Mc Graw-Hill Education
7.	Cumpsty, N. A., Jet Propulsion: A Simple Guide to the Aerodynamic and Thermodynamic Design and Performance of Jet Engines, Cambridge University Press, 2003

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify and analyze the compressible fluid flow problems by applying the fundamental technologies of fluid mechanics.
CO2	Analyze compressible flow problems with constant area & converging / diverging ducts.
CO3	Describe and evaluate the different types of shocks and their effects
CO4	Explain the effect of heat transfer and friction on fluid flow characteristics
CO5	Interpret and analyze the performance characteristics of jet propulsion engines.

Course Code	**:**	MEPE61
Course Title	**:**	**Refrigeration and Air Conditioning**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles of refrigeration and air conditioning.
CLO2	To calculate the cooling load for different applications.
CLO3	To select the right equipment for a particular cooling application.
CLO4	To design and implement refrigeration and air conditioning systems using existing standards.
CLO5	Energy Conservation and Management.

Course Content

Introduction about Refrigeration – Definitions of various terms. Methods of refrigeration. Air refrigeration system. Bell – Coleman cycle. Introduction about Aircraft Air-Conditioning.

Analysis of Vapour compression cycle, Modifications to basic cycle. Multi pressure systems. Multi-evaporator system and Cascade systems.

Discussion of components of V.C system, Servicing. Vacuumizing and charging of refrigerant. Properties of refrigerants. Selection of refrigerants. Sustainable refrigerants. Other methods of refrigeration – Vapour Absorption systems, Steam jet Refrigeration, Thermo Electric Refrigeration, Vortex Tube Refrigeration, and Magnetic Refrigeration.

Psychrometry – Definitions for properties. Introduction to cooling load calculations. Comfort conditions. Effective temperature concept.

Air-conditioning systems – discussion about the central plant with direct evaporator and chiller applications, Ice plant, refrigerators. Food preservation, IQF technique and freeze drying etc. Cold storage and thermal insulation.

References

1.	Arora, R.C., Refrigeration and Air Conditioning, PHI Pvt Ltd, 2010
2.	Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2000
3.	Dossat R.D., Principle of Refrigeration, 4th ed., Prentice-Hall, 1997.
4.	Manohar Prasad, Refrigeration and Air Conditioning, New Age International, 2004.
5.	Stoecker N.F and Jones, Refrigeration and Air Conditioning, TMH, New Delhi 2nd edition, 1982

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Illustrate the basic concepts of refrigeration system.
CO2	Analyze the vapour compression cycle and interpret the usage of refrigerants.
CO3	Understand the alternative methods of refrigeration systems.
CO4	Demonstrate the use of psychrometry in analyzing refrigeration systems.
CO5	Discuss the theory and concept of air-conditioning system

Course Code	:	MEPE62
Course Title	:	**Computational Fluid Dynamics**
Type of Course	:	Programme Elective (PE) (Stream I)
Prerequisites	:	Fluid Mechanics and Machinery (MEPC15)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce numerical modeling and its role in the field of heat transfer and fluid flow.
CLO2	To understand the various discretization methods for simplifying the differential equations
CLO3	To apply different numerical solution methods for the system of equations
CLO4	To numerically solve steady and unsteady state diffusion and convection diffusion problems
CLO5	To solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers

Course Content

Computational Fluid Dynamics: What, When, and Why? CFD Advantages and Applications, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Approximate Solutions of Differential Equations: Error Minimization Principles, Functional involving higher order derivatives, Essential and natural boundary conditions.

Discretization methods - Finite Element Method and Finite difference methods: Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples and Some Conceptual Basics and Implementation of boundary conditions. Discretization of 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme.

Important Consequences of Discretization of Time Dependent Diffusion Type Problems: Consistency, Stability, Convergence, Grid independent and time independent study, Stability analysis of parabolic and hyperbolic equations. Finite Volume Discretization of 2-D unsteady State Diffusion type problems.

Solution of Systems of Linear Algebraic Equations: Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search methods with examples. Norm of a vector, Norm of a matrix, some important properties of matrix norm, Error analysis of elimination methods.

Finite volume discretization of Convection-Diffusion Equations: Schemes. The concept of false diffusion, QUICK scheme. Discretization of Navier Stokes Equations: Discretization of the Momentum Equation, Staggered grid and Collocated grid, pressure-velocity coupling, Chorin's projection method, SIMPLE Algorithm, SIMPLER Algorithm. What is there in implementing a CFD code: The basic structure of a CFD code: Pre-processor, Solver and Postprocessor, User-defined subroutines.

References

1.	Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.
2.	Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.
3.	Anderson J.D., Computational Fluid Dynamics – The basics with Applications, Mc Graw-Hill, 1995.
4.	Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics – The finite volume method, Longman Scientific & Technical, 1995.
5.	Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.
6.	Date A.W., Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005.
7.	Ferziger, J. H., Perić, M., & Street, R. L., Computational methods for fluid dynamics, Vol. 3, Berlin: springer, 2002.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To express numerical modeling and its role in the field of fluid flow and heat transfer.
CO2	To estimate the various errors and approximations associated with numerical techniques.
CO3	To apply the various discretization methods and solution procedures to solve flow and heat transfer problems.
CO4	To perform stability analysis for different numerical schemes
CO5	To evaluate the best method for a given thermo-fluids problem.

Course Code	:	MEPE65
Course Title	:	**Convective Heat Transfer**
Type of Course	:	Programme Elective (PE) (Stream I)
Prerequisites	:	Engineering Thermodynamics (MEPC11)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize governing equations of fluid flow and heat transfer.
CLO2	To exploit order of magnitude analysis to simplify complex mathematical equations using physical understanding of problems.
CLO3	To deeply analyze forced convection heat transfer in external and internal flows
CLO4	To study the boundary layer development with free convection phenomenon
CLO5	To understand the basics of heat transfer occurring with change of phase.

Course Content

Introduction: Convection definition and review of fluid mechanics. Derivation of governing equations of mass conservation, momentum balance and energy conservation. Order of magnitude analysis, Reynolds analogy.

Forced Convective Heat Transfer in External Flows: Derivation of hydrodynamic and thermal boundary layer equations, Similarity solution techniques, Momentum and energy integral methods and their applications in flow over flat plates with low and high Prandtl number approximations. Introduction to turbulence, Reynolds averaging, Eddy viscosity and eddy thermal diffusivity, Laws of the wall.

Forced Convective Heat Transfer in Internal Flows: Concept of developing and fully developed flows. Thermally developing flows: Graetz problem. Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions. Steady forced convection in Hagen Poiseuille flow, Plane Poiseuille flow, and Couette flow and analytical evaluation of Nusselt numbers in limiting cases.

Free Convective Heat Transfer: Free convection boundary layer equations: order of magnitude analysis, similarity, and series solutions. Concept of thermal stability and Rayleigh-Benard convection.

Convection with Phase Change: Concept of boiling heat transfer and regimes in pool boiling Condensation: Nusselt film condensation theory, dropwise condensation and condensation inside tubes, effects of non-condensable Deviations from continuum: wall slip and thermal creep.

References

1.	A Bejan, Convection heat transfer. John wiley & sons, 2013.
2.	L G Leal, Advanced transport phenomena: fluid mechanics and convective transport processes. Vol. 7. Cambridge University Press, 2007.
3.	S K Som, Introduction to heat transfer. PHI Learning Pvt. Ltd., 2008.
4.	F M White, Viscous fluid flow. Vol. 3. New York: McGraw-Hill, 2006.
5.	T L Bergman, S L Adrienne, F P Incropera and D P DeWitt, Introduction to heat transfer. John Wiley & Sons, 2011.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To comprehend the governing equations involved in fluid flow and heat transfer problems.
CO2	To simplify complex mathematical equations using order of magnitude analysis.
CO3	To analyze forced and free convective heat transfer problems.
CO4	To understand the effect of different parameters on the heat transfer characteristics.
CO5	To conceptualize the similarity solution method for heat transfer analysis and study phase change effects

Course Code	:	MEPE72
Course Title	:	**Power Plant Engineering**
Type of Course	:	Programme Elective (PE) (Stream I)
Prerequisites	:	Thermal Engineering (MEPC16)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Describe sources of energy and types of power plants
CLO2	Analyze different types of steam cycles and estimate efficiencies in a steam power plant
CLO3	Describe basic working principles of gas turbine and diesel engine power plants. Define the performance characteristics of such power plants
CLO4	List the principal components and types of nuclear reactors.
CLO5	

Course Content

Thermal plant layout – working – Auxiliaries - Rankine cycle – improvement and limitations - Boiler types, circulation systems – Efficiency calculation - supercritical boilers – Fluidized bed boilers - Fuel and ash handling – combined cycle power generation.

Gas turbine power plants – Thermodynamic fundamentals, application, combined cycle configurations, cogeneration, major components, factors influencing performance of GT plants.

Hydro Electric Power Plant – Essential features, classification and operation. Prime mover – types and selection, Draft tubes – types. Ways to avoid cavitation.

Nuclear Power plants – Power reactors – Fuel cells – Current generation power reactors – Breeder reactors – components - Safety aspects.

Diesel power plants – layout – working, Different systems – Fuel system, lubrication system, Air intake system, Exhaust system, cooling system. Starting system.

Solar thermal plants and windmills – Operation & recent developments. Power plant economics.

References

1.	Arora, S.C. and Domkundwar, S., A Course in Power Plant Engineering, Dhanpat Rai & Sons, 2016.
2.	El Wakil, M.M., Power Plant Technology, Tata McGraw-Hill, 2002
3.	Nag. P.K., Power Plant Engineering, Tata McGraw-Hill, 4th Ed, 2014.
4.	Black & Veatch, “Power plant Engineering”, CBS Publisher, 2005
5.	Potter, P.J., “Power Plant Theory & Design”, Kreiger Publishing Co., 1994

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Summarize the layout and components in a power plant.
CO2	Enumerate and classify the types of power plants available.
CO3	Recognize the steam cycles on pressure-volume and temperature diagram.
CO4	Outline the scenario of entire business of power plants along with performance parameters, load curves and tariff calculations.
CO5	Extend their knowledge to power plant economics and environmental hazards

Course Code	:	MEPE74
Course Title	:	**Cryogenic Engineering** (Stream I)
Type of Course	:	Programme Elective (PE)
Prerequisites	:	Thermal Engineering (MEPC16)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To build a solid foundation in the fundamentals of cryogenics
CLO2	Evaluate the merits of Cryogenic systems and their usage
CLO3	Analyze the performance of Cryogenic systems
CLO4	Select the Cryogenic system for any given application
CLO5	Explain the available Liquefaction methods for producing liquid cryogens

Course Content

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics - Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve-Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claude Cycle Dual Pressure Cycle, Ortho-Para hydrogen conversion, Critical Components in Liquefaction Systems.

J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M. Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators

Cryogenic Dewar Design, Cryogenic Transfer Lines. Insulations in Cryogenic Systems, Different Types of Vacuum Pumps, Instruments to measure Flow, Level and Temperature.

References

1.	Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
2.	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
3.	Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1988.
4.	Herald Weinstock, Cryogenic Technology, 1969.
5.	Robert W. Vance, Cryogenic Technology, John Wiley & Sons, Inc., New York, London, 1969.

Course Outcomes

At the end of the course student will be able to

CO1	Introduce the working principles of basic methods to achieve low temperature by using adiabatic expansion, provide a thorough understanding of applications.
CO2	Able to apply classical thermodynamics to different cryogenic technologies, gas separation and purification system, and low power cryocoolers.
CO3	Understand the functions and working principles of insulations and various low temperature measuring and storage devices.
CO4	Assess the advantages of cryogenic systems and their applications.
CO5	Understand the application of Cryogenic technology in engineering research and Industry.

Course Code	**:**	MEPE84
Course Title	**:**	**Fundamentals of HVAC Systems**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn climate variation and its effects on the building heat load.
CLO2	To learn building material characteristics and their influence on building heating /cooling load for all weather conditions.
CLO3	To study various conversation techniques related to build environment and codes for the same.
CLO4	To study various Testing and Balancing Air Systems.
CLO5	To study various techniques involved in industry air conditioning systems.

Course Content

Introduction to Air Conditioning and Refrigeration – Basic Thermodynamics of HVAC, Types of Refrigeration Systems, the Refrigeration Cycle, Refrigerants and their Properties, Plotting the Refrigeration Cycle, Piping and Tubing, Soldering and Brazing, Refrigerant Leak Testing, Refrigerant System Evacuation, Refrigerant System Charging, Control Systems.

Heating systems - Gas Furnaces, Gas Furnace Controls, Gas Furnace Installation, Troubleshooting Gas Furnaces, Oil Fired Heating Systems, Oil Furnace and Boiler Service, Residential Oil Heating Installation, troubleshooting of oil heating systems, Electric Heat, Electric Heat Installation, troubleshooting of electric heat, Heat Pump System Fundamentals, Heat Pumps Applications, Geothermal Heat Pumps, Heat Pump Installation, Troubleshooting of Heat Pump Systems.

Comfort and Psychometrics - Fundamentals: Psychometrics & Airflow, Air Filters, Ventilation and Dehumidification, Heat transmission in building structures -Solar radiation -Infiltration and Ventilation-Cooling/heating load calculations, Residential Load Calculations, Green Buildings and Systems, Indoor Air Quality (IAQ), Building energy calculations

Duct Installation, Duct Design, Zone Control Systems, Testing and Balancing Air Systems.

Chilled Water Systems, Cooling Towers, Commercial Refrigeration Systems, Supermarket Equipment, Ice Machines.

References

1.	Handbook of heating, ventilation and Air-conditioning, Jan. F. Kreider, CRC press.
2.	Automotive heating and Air-conditioning, Mike Stubblefield and John H Haynes
3.	Heating ventilation and air conditioning – Jan F. Kreider
4.	Control systems for Heating, ventilating and air conditioning, Roger W. Haines, Springer
5.	HVAC Equations, Data, and Rules of Thumb - Arthur A. Bell Jr., PE, McGraw-Hill

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Estimate heating loads, space heat gains and space cooling loads using accepted engineering methods.
CO2	Determine the coil loads for cooling and heating systems.
CO3	Select equipment and design systems to provide comfort conditions within the building.
CO4	Understand different testing and balancing air conditioning systems
CO5	To apply the principles of producing air conditioning for human comfort and industry applications

Course Code	**:**	MEPE85
Course Title	**:**	**Alternative Refrigerants**
Type of Course	**:**	Programme Elective (PE) (Stream I)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	understand the importance of refrigerant and its properties
CLO2	understand the impact of refrigerants on the environment.
CLO3	understand the safety measures applicable for refrigerants.
CLO4	To provide design procedures with alternative refrigerants.
CLO5	To identify the changes in retrofitting the systems with alternative refrigerants

Course Content

Refrigerants and its classification – Need of alternate refrigerants, Desirable properties- thermodynamic-chemical and transport properties - designation of refrigerants - inorganic, halo carbon refrigerants - secondary refrigerants - Properties of mixtures of refrigerants, Ozone depletion potential and global warming potential.

Flammability of the alternate refrigerants, methods for identifying the safe zone of operation, Measuring the financial and environmental impact of leakage of refrigerants on the environment, Refrigerant Hazards.

Safety and risk assessment of alternative refrigerants, System design using alternative refrigerants, Leak detection of alternative refrigerants, Maintenance and repair of alternative refrigerant systems, Retrofitting existing systems

References

1.	Arora, R.C., Refrigeration and Air Conditioning, PHI Pvt Ltd, 2010
2.	Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2000 Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3.	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
4.	Randall F. Barron, Cryogenic heat transfer, CRC Press,1999.
5.	becker N.F and Jones, Refrigeration and Air Conditioning, TMH NewDelhi,2nd edition 1982.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To comprehend the significance of refrigerants and their characteristics.
CO2	To recognize the environmental impact of refrigerants.
CO3	To understand the safety protocols associated with refrigerants.
CO4	To offer design guidelines for using alternative refrigerants.
CO5	To identify the modifications required when retrofitting systems with alternative refrigerants.

Programme Elective (PE) Courses – 2/3

Stream II (Design Engineering)

Sl. No.	Course Code	Course Title	Credits
1.	**MEPE31**	Computer Aided Design and Drafting	3
2.	**MEPE35**	Machine Drawing	3
3.	**MEPE36**	Introduction to AI & ML for Mechanical Engineering	3
4.	**MEPE42**	Continuum Mechanics	3
5.	**MEPE51**	Advanced Mechanics of Solids	3
6.	**MEPE63**	MEMS Devices – Design and Fabrication	3
7.	**MEPE64**	Mechanical Vibrations and Acoustics	3
8.	**MEPE71**	Finite Element Method	3
9.	**MEPE75**	Vehicle Dynamics	3
10.	**MEPE76**	Fundamentals of Biomechanics	3
11.	**MEPE77**	Mechanics of Composite Materials	3
12.	**MEPE82**	Introduction to Fracture Mechanics	3
13.	**MEPE83**	Dynamics of Machinery	3

Course Code	**:**	MEPE31
Course Title	**:**	**Computer Aided Design and Drafting**
Type of Course	**:**	Programme Elective (PE) (Stream II)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Introduce the student to the basic tools of computer-aided design (CAD) and computer-aided manufacturing (CAM).
CLO2	Expose the student to contemporary computer design tools for aerospace and mechanical engineers.
CLO3	Prepare the student to be an effective user of a CAD/CAM system.
CLO4	Apply mathematical techniques for representing and manipulating geometric entities
CLO5	Develop and modify solid models using feature-based approaches

Course Content

CAD hardware - Product cycle - CAD tools, CAD systems; system evaluation, CAD specific I/O devices.

CAD software - Graphic standards – Modes of graphics operation, Software Modules.

Geometric modeling – Types and mathematical representation and manipulation of curves and surfaces.

Solid modeling- fundamentals, feature based modeling manipulations of solid models. Transformation of Geometric models and visual realism - Animation.

References

1.	Zeid, I., CAD/CAM Theory and Practice, Tata McGraw-Hill, 2nd Edition, 2009.
2.	Rogers, D.E and Adams, J.A., Mathematical Elements for Computer Graphics, 2nd ed. McGraw-Hill, 2002.
3.	Anupam Saxena and Birendra Sahay, Computer Aided Engineering Design, by ISBN-13: 978-1402025556, Springer, 2005.
4.	Farid M. L. Amirouche, Principles of Computer-aided Design and Manufacturing, Pearson Prentice Hall, 2004.
5.	Ruben Hawkins , Computer Graphics: Principles and Practice, Larsen and Keller Education, 2017

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Effectively use CAD software and tools to create, modify, and manage both 2D and 3D designs.
CO2	Apply principles of geometric modeling to represent and manipulate curves, surfaces, and solid objects.
CO3	Apply industry-standard graphic formats and conventions in their CAD work
CO4	Use mathematical methods to represent and manipulate curves and surfaces,
CO5	Perform geometric transformations on CAD models and enhance visual realism.

Course Code	**:**	MEPE35
Course Title	**:**	**Machine Drawing**
Type of Course	**:**	Theory – Programme Elective
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Interpret and prepare sectional and auxiliary views of machine components using BIS/ISO standards.
CLO2	Apply manufacturing and functional considerations while dimensioning mechanical components.
CLO3	Create production-ready machine drawings and interpret industrial engineering drawings.
CLO4	Prepare detailed drawings of standard machine elements with appropriate dimensions, tolerances, and surface finish symbols.
CLO5	Develop assembly drawings and generate part drawings from assembled systems.

Course Content

Fundamentals of Machine Drawing - Review of orthographic projections, Sectional views (full, half, offset, broken-out), Auxiliary views, Conventional representation of materials, Thread representation (internal, external), Fasteners drawing conventions, BIS / ISO drawing standards, Limits, fits and tolerances, Surface finish symbols, Geometric Dimensioning & Tolerancing (GD&T basics).

Manufacturing Considerations in Drawing- Machining allowances, Fits (clearance, transition, interference), Surface roughness and finishing symbols, Welding symbols, Casting & forging allowances, Tolerance stack-up basics

Drawing of Machine Elements- Bolts, nuts, washers, Keys, cotters, knuckle joints, Couplings (rigid & flexible), Bearings (journal & rolling element), Springs (helical compression/tension), Pulleys & flywheels.

Assembly Drawing & Interpretation - Principles of assembly drawing, Bill of Materials (BOM), Exploded views, Sectional assembly views, Interpretation of given assembly drawings, Disassembly into part drawings

- Screw jack assembly,
- Footstep bearing,
- Plummer block,
- Tool post assembly

References

1.	N. D. Bhatt, MACHINE DRAWING, Charotar Publishing House Pvt. Ltd., 2022.
2.	K.L. Narayana, P. Kannaiah, K. Venkata Reddy, Machine Drawing, New Age International, 2019.
3.	P.S. Gill, A Textbook Of Machine Drawing, VISIONIAS, 2021. .
4.	Dr. RK Dahwan, A Textbook of Machine Drawing, S Chand & Company, 2015.
5.	Engineering Drawing Practices for Schools and Colleges, SP:46, Bureau of Indian Standards.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Produce accurate machine component drawings following BIS/ISO standards and conventions.
CO2	Apply manufacturing constraints and functional requirements in mechanical drawing.
CO3	Prepare detailed part drawings incorporating limits, fits, and surface finish requirements.
CO4	generate professional machine drawings and assembly documentation.
CO5	Develop and interpret assembly drawings and extract individual component drawings.

Course Code	**:**	MEPE36
Course Title	**:**	**Introduction to AI & Machine Learning for Applications in Mechanical Engineering**
Type of Course	**:**	Programme Elective (PE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To explain the fundamental concepts of Artificial Intelligence and Machine Learning and their relevance to mechanical engineering applications.
CLO2	To develop the mathematical formulation of linear and multidimensional regression using matrix methods and optimization techniques.
CLO3	To analyze model performance using concepts such as bias, variance, overfitting, and generalization.
CLO4	To understand the structure and working of artificial neural networks through forward propagation and basic learning concepts.
CLO5	To apply machine learning techniques to simplified mechanical engineering problems and interpret the results in comparison with analytical models.

Course Content

Introduction to Artificial Intelligence and its evolution, distinction between Narrow AI and General AI, fundamentals of Machine Learning as data-driven modeling, supervised learning with emphasis on regression, hypothesis function and model parameters, training and prediction framework, cost function and error minimization concept, overview of applications of machine learning in mechanical engineering such as predictive maintenance, manufacturing analytics, heat transfer data modeling, material property estimation, and limitations of machine learning compared to physics-based modeling.

Simple linear regression using least squares method, formulation of Mean Squared Error (MSE) cost function, analytical minimization of cost function, derivation of normal equations, matrix formulation of linear regression ($Y = XW$), multidimensional linear regression, geometric interpretation as projection in vector space, numerical problems solvable manually including 2×2 matrix inversion.

Polynomial regression and nonlinear curve fitting using linear regression framework, feature transformation and basis functions, bias and variance concepts, bias–variance tradeoff, overfitting and underfitting, introduction to regularization concept, convex optimization in linear regression, introduction to gradient descent algorithm with basic update rule and small numerical illustration.

Biological inspiration of artificial neural networks, structure of artificial neuron, weighted sum and activation function, single-layer perceptron model, step and sigmoid activation functions, forward propagation in single-layer networks, two-layer neural network structure with two or three inputs, manual forward computation examples, concept of backpropagation using chain rule idea, distinction between linear and nonlinear models.

Data-driven modeling of heat transfer relationships, load–deflection prediction using regression models, material property estimation from experimental datasets, comparison between analytical modeling and machine learning-based prediction, limitations of data-driven methods, responsible and ethical use of AI in engineering practice.

References

1.	Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, An Introduction to Statistical Learning, Springer
2.	Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, O'Reilly (selected conceptual sections)
3.	Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press
4.	S. S. Rao, Engineering Optimization: Theory and Practice, Wiley,
5.	Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning, Springer.

Course Outcomes

At the end of the course student will be able

CO1	Explain the basic principles of AI and machine learning and identify their applications in mechanical engineering.
CO2	Formulate and solve linear and multidimensional regression problems using analytical and matrix-based approaches.
CO3	Analyze model behavior using bias–variance concepts and evaluate issues such as overfitting and underfitting.
CO4	Compute outputs of single-layer and simple multi-layer neural networks through manual forward propagation.
CO5	Apply data-driven modeling techniques to basic mechanical engineering problems and compare them with traditional analytical methods.

Course Code	:	MEPE42
Course Title	:	**Continuum Mechanics**
Type of Course	:	Programme Elective (PE) (Stream II)
Prerequisites	:	Mechanics of Solids (MEPC14)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce indicial notation for vector and tensor operations
CLO2	To introduce basic tonsorial calculus for understanding continuum behavior of matters.
CLO3	To familiarize the kinematics of continuum body deformation.
CLO4	To familiarize the configuration dependent stress measures.
CLO5	To understand the fundamental balance principles of continuum objects.

Course Content

Tensor - Introduction: Scalar, Vector, Second order Tensors, Indicial notation and summation convention, Dot, cross and dyadic products, Linear Transformation, Spherical & deviatoric projectors, Coordinate Transformation, dual basis.

Tensor - Calculus: Eigen values & eigen vectors, Transformation of Tensors, Tensor valued functions, gradient operators and Integral theorems.

Kinematics: Reference and deformed configurations, motion – velocity and acceleration in material & spatial representation, Deformation and displacement gradients, material and spatial stains measures, Line, area, and volume mappings, Nanson's formula, Polar decomposition - Rotation & stretch tensors, rate of deformation.

Kinetics: Concept of stress, Cauchy's stress theorem, first and second Piola-Kirchoff's & Cauchy's stress tensors, Normal and shear stress, Extremal stress values, stress states.

Balance Principles: Mass conservation, Reynold's transport theorem, Momentum and energy balances in references and current configuration, Weak and strong forms of balance equation, Continuum thermodynamics, Clausius-Duhem inequality, Frame dependent and independent quantities, Objective rates.

References

1.	Gerhard A. Holzapfel, Nonlinear solid mechanics: A Continuum approach for Engineering, Wiley, ISBN: 978-0-471-82319-3 ,2000.
2.	W Michael Lai, David H. Rubin, Erhard Krempl, David Rubin, Introduction to Continuum Mechanics, Butterworth-Heinemann; 4th edition, ISBN: 978-9380501581.
3.	J.N. Reddy, An Introduction to Continuum Mechanics, Cambridge University Press; 2nd edition, ISBN: 978-1316614204.
4.	George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw Hill; First edition, ISBN: 978-9389691283
5.	John W. Rudnick, Fundamentals of Continuum Mechanics, Wiley, ISBN: 978-1-118-92767-0, 2014.
6.	Mysore N. L. Narasimhan, Principles of Continuum Mechanics, Wiley-Interscience, ISBN: 978-0471540007, 1992.
7.	Fridtjov Irgens, Continuum mechanics, Springer, ISBN: 978-3-540-74297-5, 2008.
8.	**C.S. Jog,** Continuum Mechanics: Volume 1: Foundations and Applications of Mechanics, Cambridge University Press, 978-1107091351, 2015.
9.	Bertram, Albrecht. Elasticity and plasticity of large deformations. Springer-Verlag Berlin Heidelberg, 2005.
10.	Shabana, Ahmed A. Computational continuum mechanics. John Wiley & Sons, 2018.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To use indicial notation and Einstein's summation convention for tensor operations.
CO2	To represent physical parameters in tensorial notations and perform tensor calculus.
CO3	To understand the unified theory of continuum body such as fluids and solids undergoing deformation.
CO4	To acknowledge the stress and strain on a material and spatial point.
CO5	To derive the linear momentum balance in material and spatial configuration.

Course Code	**:**	MEPE51
Course Title	**:**	**Advanced Mechanics of Solids**
Type of Course	**:**	Programme Elective (PE) (Stream II)
Prerequisites	**:**	Mechanics of Solids (MEPC14))
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart concept of stress and strain analysis in solids.
CLO2	To familiarize with 2D problems in elasticity and its solutions.
CLO3	To imbibe knowledge of elastic problems in polar coordinates.
CLO4	To acquaint with the solution of advanced bending problems.
CLO5	To understand torsional problems in elasticity.

Course Content

Strain: Tensor notations - Displacement field – engineering strain – strain tensor – Strain-displacement relations – Compatibility conditions – Strain transformation – Principal strains and planes. **Stress:** Stress at a point – Traction vector and Stress tensor – Stress components in rectangular coordinate systems – Cauchy's equations. Stress transformation – Principal stresses and planes – Hydrostatic and deviatoric stress components – Octahedral stress – Equations of equilibrium.

Constitutive Relations: Generalized Hooke's law – Stress-Strain relations for isotropic materials – Elastic constants – Relation between elastic constants - anisotropy. Saint-Venant's principle for end effects – General theorems of uniqueness, Linear superposition, and reciprocity – Castigliano's Theorem, thermoelastic behavior of materials.

2D Elasticity: Plane stress and plane strain problems – Stress compatibility equation – Airy's stress function and equation – Polynomial method of solution – Solution for bending of a cantilever beam with an end load.

Elastic Problems in Polar Coordinates: Analogy between polar and rectangular coordinates – Equilibrium equations – Airy's stress function in polar coordinates – Application in Stress Concentration problems – Axisymmetric problems – Plate with a hole – Thick-walled cylinder and rotating discs.

Unsymmetrical Bending: Unsymmetrical bending of straight beams – Curved beams – Shear center of thin-walled open sections with one axis of symmetry.
Torsion: Torsion of non-circular bars – Solutions for circular and elliptical cross-sections using Saint-Venant's theory and Prandtl's method – Torsion of thin-walled tubes – Shear flow.

References

1.	Timoshenko, S. and Goodier, J.N., 2010. Theory of Elasticity. Tata McGraw-Hill.
2.	Boresi, A.P., Schmidt, R.J. and Sidebottom, O.M., 2002. Advanced mechanics of materials. Wiley Publications, ISBN: 978-0-471-43881-6.
3.	Sadd, M.H., 2009. Elasticity: Theory, Applications, and Numerics. Elsevier Academic Press.
4.	Srinath, L.S., 2008. Advanced Mechanics of Solids. Tata McGraw-Hill.
5.	Dym, C.L. and Shames, I.H., 2013. Solid Mechanics: A Variational Approach. Springer.
6.	Popov, E.P., 2015. Engineering Mechanics of Solids. Pearson Education India.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To apply concepts of stress and strain analyses in solids.
CO2	To understand the effects of temperature change in elastic materials.
CO3	To formulate and solve 2D problems in elasticity.
CO4	To estimate the stress field in axisymmetric problems.
CO5	To solve general bending and torsional problems.

Course Code	**:**	MEPE63
Course Title	**:**	**MEMS Devices – Design and Fabrication**
Type of Course	**:**	Programme Elective (PE) (Stream II)
Prerequisites	**:**	Mechanics of Solids (MEPC14)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To present the sensing and actuation principles of various microsystems.
CLO2	To impart knowledge on the material properties, basic structural mechanics, circuit and system issues, packaging, calibration, and testing.
CLO3	To identify the characteristics of various semiconducting materials.
CLO4	To introduce the scaling laws of miniaturized MEMS devices.
CLO5	To design, analysis and master simulation techniques for combining a structured top-down system design approach with bottom-up constraints propagation design and simulate microsystems using behavioral modeling languages and finite element analysis.

Course Content

An overview of microelectromechanical system (MEMS) and devices; typical product – Micro Gear, Micro Motors, Micro turbines and other related products. Working Principles of Microsystems – Micro sensors, Micro Actuators: Various micro actuation systems; MEMS integrated with mechanical actuation and Inertial actuation: Micro fluidics.

Review of Mechanical concepts: Stress, Strain, Modulus of 15% Elasticity, yield strength, ultimate strength – General stress strain relations – compliance matrix. Overview of commonly used mechanical structures in MEMS - Beams, Plates, diaphragms – Typical applications.

Materials for MEMS and Microsystems – Silicon and silicon compounds, Gallium, Piezoelectric and piezoresistive materials, Polymers and metals.

Introduction to design and modeling; Scaling laws in miniaturization; Standard microelectronic fabrication technologies - bulk micromachining - surface micromachining - bonding technologies; Role of Finite Element Analysis software in MEMS.

References

7.	Tai – Ran Hsu, MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering, John Wiley & Sons, 2008.
8.	Tai – Ran Hsu, MEMS & Microsystems Design and Manufacturing, Tata McGraw-hill Edition, 2006
9.	Stephen D. Senturia, Microsystems Design, Springer Science & Business Media, 2007.
10.	Nadim Maluf, Kirt Williams, Introduction to Microelectromechanical Systems Engineering, Artech House, 2004.
11.	Mohamed Gad-el-Hak, MEMS: Design and Fabrication, Taylor & Francis Limited, 2019.
12.	Marc J. Madou, Fundamentals of Microfabrication, the science of Miniaturization, CRC Press, 2018.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply engineering knowledge to understand the working principles of micro sensors and actuators.
CO2	Design and analyze the beams, plate and diaphragm of MEMS devices.
CO3	Understand the suitable materials for fabrication of micro systems through literature survey.
CO4	Identify the standard and economic micro fabrication techniques that leads to environmentally friendly and social needs.
CO5	Get an experience in the advanced CAD modeling and simulation tools like COMSOL, ANSYS and IntelliSuite to design, analyze and simulate the designed micro devices.

Course Code	**:**	MEPE64
Course Title	**:**	**Mechanical Vibrations and Acoustics**
Type of Course	**:**	Programme Elective (PE) (Stream II)
Prerequisites	**:**	Mechanics of Machines – II (MEPC20)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of vibration.
CLO2	To develop the two degree of freedom systems.
CLO3	To formulate the multi degree of freedom systems
CLO4	To study the vibration test & measurements and devise the vibration controlling methods.
CLO5	To impart knowledge on acoustics and its control.

Course Content

Fundamentals of Vibrations - Harmonic and periodic motions, Vibration terminology, Vibration model - Equations of motion - Energy method - Rayleigh method - Principle of virtual work, damping models - Viscously damped free vibration, Special cases: oscillatory, non-oscillatory and critically damped motions, Logarithmic decrement, Forced harmonic vibration - Magnification factor – Transmissibility.

Two degree – Normal mode analysis – Translational system - Rotor system - Lagrangian energy method - Coordinate coupling.

Multi degree - Eigen value and vector - Linear system - Matrix method - Influence coefficients - Stiffness - Flexibility, Numerical methods - Holzer's method - Rayleigh's Approach - Dunkerley's method.

Experimental modal analysis - Free and Forced vibration tests - Frequency response function (FRF), Methods of vibration control - Excitation reduction at source, Vibration isolation techniques - Active control - passive control.

Fundamentals of acoustics, Plane wave, propagation, radiation and scattering, effect of noise on human, acoustics measurement techniques, Noise reduction methods

References

1.	Thomson, W.T., Theory of Vibration and its Applications, 5th Edition, Prentice Hall, New Delhi, 2010.
2.	Rao, S.S., Mechanical Vibrations, 5th Edition, Pearson Education Inc. Delhi 2017.
3.	Meirovitch, L., Elements of Vibration Analysis, 2nd Edition, Mc Graw-Hill Book Co., New York, 1993.
4.	Dukkipati, R.V., Advanced Mechanical Vibrations, Narosa Publications, 2008.
5.	David A. Bies and Colin H. Hansen, Engineering Noise Control: Theory and Practice Spon Press, London. 2009.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To review the fundamentals of vibration and formulate the differential equations of the given vibration models.
CO2	To develop the equation of motion for the two degrees of freedom system.
CO3	To model the equation of motion for the multi degrees of freedom system based on various numerical methods.
CO4	To study the vibration tests, measurements and control of the machinery components.
CO5	To apply the acoustics measurement techniques and noise reduction methods to machineries.

Course Code	:	MEPE71
Course Title	:	**Finite Element Method**
Type of Course	:	Programme Elective (PE) (Stream II)
Prerequisites	:	Mechanics of Solids (MEPC14)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Appreciate the classical approximation methods and the history of FEM.
CLO2	To familiarize Galerkin method and derive weak form of GDE.
CLO3	To understand the finite element method for 1-D scalar problems.
CLO4	To understand the Gauss-Quadrature for numerical integration
CLO5	To apply FEM for structural mechanics problems

Course Content

Classical approximation methods: Approximate solution of boundary value problems (BVP), Methods of weighted residuals, variational method, Modified Galerkin method, Collocation method, Essential boundary conditions and Natural boundary conditions., solution of 1-D GDE with boundary conditions.

FEM–1D scalar: Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Weak form using modified Galerkin method, **Application:** Axial deformation of bars, Axial Spring element, Analysis of trusses-2-D element, 3-D space truss element, General 1-D boundary value problem and its applications-1-D heat flow, Fluid flow between flat plates- Lubrication Problem, Column buckling.

Beam bending: GDE for beam bending, 2-D beam element, Exact solution for uniform beams subjected to distributed loads using superposition, Calculation of stresses in beams, Thermal stresses in beams.

FE order and numerical integration: Higher order elements for one dimensional problems-Shape functions for second order problems, isoparametric mapping concept, Quadratic element for general 1-D BVP, One dimensional numerical integration, Application: Heat conduction through a thin film, 2-D BVP using triangular elements, Equivalent functional for general 2D BVP, A triangular element for general 2D BVP, shape functions for rectangular elements, Newton-Cotes rules, Trapezium rule, Simpsons rule, Error term, Gauss-Legendre rules, Changing limits of integration, Gauss-Leguerre rule, Numerical integration for quadrilateral elements, 4 - noded quadrilateral element for 2D BVP, 8-noded serendipity element for 2D BVP.

Solid Mechanics: Two-dimensional elasticity and GDE, Constant strain triangular element, 4-noded quadrilateral element, 8-noded isoperimetric element, axisymmetric elasticity problems, Axisymmetric linear triangular element, Axisymmetric 4-noded 2-D element, 3-D elasticity, 4-noded tetrahedral element, 8- noded hexahedral (brick-3D) element, initial strains and thermal effects. Dynamics problems in structural mechanics

References

1.	Zienkiewicz, O.C., and Taylor, R.L., TheFinite Element Method, 6th Ed., Vol.1, Elsevier, 2005.
2.	Bathe, K-J., FiniteElementProcedures,Prentice Hall, 1996.
3.	Cook, R. D., Malkus, D. S., Plesha, M. E.,and Witt, R.J.,Concepts and Applications of Finite Element Analysis, 4thEdition, Wiley-India,2007.
4.	Hughes, T. J. R.,The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
5.	Seshu, P., Textbook of Finite Element Analysis, Prentice-Hall, India, 2003.
6.	Segerlind, L.J., Applied Finite Element Analysis, John Wiley, 1987.
7.	M.Asghar Bhatti “Fundamental Finite Element Analysis and Applications” John Wiley & sons, ISBN – 978-8126539345, 2013.
8.	Lewis R.W.Morgan, K, Thomas, H.R. and Seetharaman, K.N. The Finite Element Method in Heat Transfer Analysis, John Wiley, 1994.
9.	Edward R Champion Jr, “Finite Element Analysis in Manufacturing Engineering”, McGraw Hill, 1992.
10.	Hughes, T. J. R.,The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
11.	J.N.Reddy, An Introduction to the Finite Element Method, McGraw-Hill Education India, 2006.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To solve BVP using classical methods without using FEM.
CO2	To derive weak form and discretize using finite element method.
CO3	To numerically solve the beam bending with complex boundary conditions.
CO4	To do volume and surface integrals numerically using local co-ordinate system.
CO5	To solve linear elasticity problems

Course Code	**:**	MEPE75
Course Title	**:**	**Vehicle Dynamics**
Type of Course	**:**	Programme Elective (PE) (Stream II)
Prerequisites	**:**	Mechanics of Machines – II (MEPC20)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the vibration of SDOF and MDOF vibrational systems.
CLO2	To understand various numerical techniques used to evaluate the natural frequencies and mode shapes of MDOF systems.
CLO3	To impart the knowledge of vehicle load distribution while acceleration, deceleration, and braking.
CLO4	To study the mechanical properties of tires and their rolling resistance.
CLO5	To understand the lateral and vertical dynamics of vehicle.

Course Content

Fundamentals of Vibration: Review of free, forced, and damped vibrations of Single Degree of Freedom Systems (SDOF). Multi Degree of Freedom Systems: Close-coupled system, Eigen valve problems, Far-coupled systems, Orthogonality of mode shapes, Modal analysis, Forced vibration by matrix inversion.

Numerical Methods: Approximate methods for fundamental frequency – Dunkerley's lower bound method, Rayleigh's upper bound method, Holzer method for close-coupled systems.

Longitudinal Dynamics: Vehicle load distribution – Acceleration and Braking, Brake force distribution, Braking efficiency and braking distance, Passenger car and Tractor-semi trailer models.

Tire Mechanics: Mechanical properties of rubber – Slip, grip and rolling resistance, Tire construction and force development, contact patch and contact pressure distribution, Tire Brush Model, Lateral force generation – ply steer, conicity, and camber, Magic Formula Tire Models, Combined Slip.

Lateral dynamics: Bicycle Model, Stability and steering conditions, Understeer gradient, Handling response of a vehicle, Parameters affecting vehicle handling characteristics, Rollover prevention. **Vertical Dynamics:** Full car model, Half car model, Quarter car model.

References

1.	Thomson, W.T., 2010. Theory of Vibration and its Applications, 5th Edition, Pearson Eduation, New Delhi.
2.	Rao, J.S., 1999. Introductory Course on Theory and Practice of Mechanical Vibrations. New Age International.
3.	Gillespie, T., 1992. Fundamentals of Vehicle Dynamics. SAE international.
4.	Pacejka, H., 2006. Tire and Vehicle Dynamics. Elsevier.
5.	Wong, J.Y., 2008. Theory of Ground Vehicles. John Wiley & Sons.
6.	Karnopp, D., 2004. Vehicle Stability. CRC Press.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To illustrate the fundamentals of vibration and formulate the differential equations of the given vibration models.
CO2	To evaluate the natural frequencies and mode shapes of MDOF systems by appropriate numerical techniques.
CO3	Analyze road vehicles for their longitudinal dynamic response during acceleration and braking.
CO4	To design tires which provide proper rolling resistance and contact pressure distribution.
CO5	To evaluate road vehicles for their lateral and vertical dynamic response while cornering and moving on a rough patch of the road.

Course Code	**:**	MEPE76
Course Title	**:**	**Fundamentals of Biomechanics**
Type of Course	**:**	Programme Elective (PE) (Stream II)
Prerequisites	**:**	Engineering Mechanics (MEPC10)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The principles of mechanics and their application in biomechanics.
CLO2	Biomechanics of skeletal joints and tissues.
CLO3	Solving equations of motion for simple models of human movement.
CLO4	Applying biomechanics principles to implant design and gait analysis.
CLO5	Developing skills in biomechanical analysis and problem-solving.

Course Content

Introduction to Biomechanics- Review of the principles of mechanics, Vector mechanics, biomechanics, anatomical terminology, Anthropometry, motion in the human machine.

Biomechanics of Joints- Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle, Introduction to bio fluid Mechanics, Rheological properties of blood, laminar flow, Couette flow and Hagen Poiseuille equation, turbulent flow.

Hard and Soft Tissue- Bone structure, composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, maxwell & voight models, Structure and functions of Soft Tissues: Cartilage, Tendon, Ligament, and Muscle; Material Properties: Cartilage, Tendon, Ligament, and Muscle; Modeling of soft tissues, Hills's muscle model.

Cardiovascular and Respiratory Mechanics– Cardiovascular system, artificial heart valves, biological and mechanical valves development, testing of valves, Blood Flow Models, Blood Vessel Mechanics, Heart valve dynamics, prosthetic valve dynamics. Mechanism of air flow, respiratory cycle, lung ventilation model, methods of determining pressure, flow rate and volume spirometry.

Applied Biomechanics and Biomechanics of Implants- Engineering approaches to standing, sitting and lying, Biomechanics of gait, application of gait and locomotion analysis, Fluid mechanics and energetics: Forms of energy and energy transfer, Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.

References

1.	Ronald Huston, “Principles of Biomechanics”, CRC Press - 1st Edition, 2019, ISBN: 978-0367452469
2.	Susan J.Hall, “Basic Bio Mechanics”, McGraw -Hill Publishing Co, Newyork - 8th Edition, 2019, ISBN: 978-1259913877.
3.	Zatsiorsky and Prilutsky, Biomechanics of Skeletal muscles, Human Kinetics publishers, 2012.
4.	Valdimir M. Zatsiorsky, “Kinetics of Human motion”, Human Kinetics publishers, 2002, ISBN: 978-0736037785.
5.	Vladimir M. Zatsiorsky, and Boris I. Prilutsky, “Biomechanics of Skeletal muscles”, Human Kinetics publishers - 1st Edition, 2012, ISBN: 978-0736080200.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze and apply the principles of mechanics to solve problems in biomechanics and human movement analysis.
CO2	Assess the forces and stresses in human joints and tissues, using free- body diagrams and biomechanical analysis techniques to evaluate the functionality and limitations of different anatomical structures.
CO3	Model the mechanical properties of hard and soft tissues, such as bones, cartilage, tendons, ligaments, and muscles, and predict their behavior under various conditions and loads.
CO4	Design, develop, and evaluate prosthetic and orthopedic implants, considering biomechanical requirements, biocompatibility, and material characteristics to enhance patient outcomes.
CO5	Apply knowledge of cardiovascular and respiratory mechanics to interpret and predict the behavior of blood flow and respiratory dynamics, and to evaluate the performance of artificial heart valves and respiratory models.

Course Code	:	MEPE77
Course Title	:	**Mechanics of Composite Materials**
Type of Course	:	Programme Elective (PE) (Stream II)
Prerequisites	:	Mechanics of Solids (MEPC14)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of composite materials behavior.
CLO2	To impart knowledge on micromechanics of composite materials.
CLO3	To analyze the laminate stress-strain relations.
CLO4	To develop the governing equations for different laminates.
CLO5	To study the failure criteria and composite repair techniques.

Course Content

Classification and characteristics of composite materials - Types of fiber and resin materials, functions and their properties – Application of composite to aircraft structures-Micromechanics-Mechanics of materials, Elasticity approaches-Mass and volume fraction of fibers and resins-Effect of voids, Effect of temperature and moisture.

Hooke's law for orthotropic and anisotropic materials-Lamina stress-strain relations referred to natural axes and arbitrary axes.

Governing equations for anisotropic and orthotropic plates- Angle-ply and cross ply laminates-Analysis for simpler cases of composite plates and beams - Interlaminar stresses.

Netting analysis- Failure Criteria-Flexural rigidity of Sandwich beams and plates – composite repair- AE technique

References

1.	R.M. Jones, Mechanics of Composite Materials, 2nd Edition, Taylor & Francis, 2010.
2.	L.R. Calcote, Analysis of laminated structures, Van Nostrand Reinhold Co., 1989.
3.	Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997.
4.	B.D. Agarwal and L.J. Broutman, Analysis and Performance of fiber composites, John-Wiley and Sons, 1990.
5.	Daniel, Isaac M., Ori Ishai, Issac M. Daniel, and Ishai Daniel, Engineering mechanics of composite materials. Oxford university press, 2006.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Classify and characterize the composite materials.
CO2	Apply the micromechanics approach to evaluate the composite materials properties.
CO3	Analyze the different composite laminates based on classical laminate theory (CLT).
CO4	Apply the failure criteria of composite laminates.
CO5	Implement to composite repair techniques.

Course Code	**:**	MEPE82
Course Title	**:**	**Introduction to Fracture Mechanics**
Type of Course	**:**	Programme Elective (PE) (Stream II
Prerequisites	**:**	Mechanics of Solids (MEPC14)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the basic concepts of fracture mechanics.
CLO2	To impart knowledge on linear elastic fracture mechanics.
CLO3	To study the behavior of materials undergoing elastic plastic fracture.
CLO4	To understand the experimental testing of plane strain fracture toughness.
CLO5	To study crack propagation under fatigue loading.

Course Content

Basic concepts of fracture mechanics, History of fracture mechanics, Types of fracture, Modes of loading, Types of cracks, Classification of fracture mechanics – LEFM and EPFM, Fracture mechanics approach to design, Solution of fracture mechanics problems – damage tolerance, Applications of fracture mechanics.

Linear Elastic Fracture Mechanics (LEFM) – Griffith theory, Energy release rate (G), Instability and R-curve. Stress analysis of cracks – Stress intensity factor (K), Relationship between K and G, Crack tip plasticity. Mixed mode crack propagation.

Elastic Plastic Fracture Mechanics (EPFM) – Crack tip opening displacement (CTOD), Relationship between K and CTOD, CTOD Design curve. J-integral – Nonlinear energy release rate, Relationship between J and CTOD.

Experimental determination of plane strain fracture toughness, K- R curve testing, CTOD testing, J measurement.

Fatigue crack propagation – Constant amplitude cyclic loading, Paris' law and Forman's equation, Crack closure phenomenon, Retardation of crack growth due to overloads. Variable amplitude cyclic loading.

References

1.	Anderson, T.L., 2005. Fracture mechanics: fundamentals and applications. CRC press.
2.	Broek, D., 2012. Elementary Engineering Fracture Mechanics. Springer Science & Business Media.
3.	Kumar, P., 2009. Elements of Fracture Mechanics. McGraw-Hill Education LLC.
4.	Maiti, S.K., 2015. Fracture Mechanics: Fundamentals and Applications. Cambridge University Press.
5.	Liu, A.F., 2005. Mechanics and mechanisms of fracture: an introduction. ASM International.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the fundamental concepts of fracture mechanics.
CO2	To derive the governing equations for the linear elastic fracture mechanics.
CO3	To understand the mechanism of elastic plastic fracture mechanics and formulate the relationship between J-integral and CTOD.
CO4	To know how the plane strain fracture toughness tests are carried out experimentally.
CO5	To under the behavior of structures undergoing fatigue crack propagation.

Course Code	:	MEPE83
Course Title	:	**Dynamics of Machinery**
Type of Course	:	Programme Elective (PE) (Stream II
Prerequisites	:	Mechanics of Machines – II (MEPC20)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the force-motion relationship of components subjected to external forces
CLO2	To analyze the force-motion characteristics of standard machine elements
CLO3	To study the undesirable effects of unbalances resulting from prescribed motions in mechanism.
CLO4	To understand the importance of damping
CLO5	To reduce the physical vibratory system into spring and damping elements

Course Content

Fundamentals: Types of vibrations, spring and damping elements, Single degree of freedom systems – free undammed: translations, torsional vibrations, Rayleigh's Energy method. **Free damped vibrations:** viscous damping-coulomb damping.

Forced vibration: harmonic force, rotating unbalance / base excitation, concept of frequency response function (FRF), damping-coulomb and hysteresis, transfer functions. General periodic force, Laplace transform.

Two degree of freedom systems – free-undamped, forced, coupling, introduction to multi-DOF systems.

Vibration of continuous systems: transverse vibration, longitudinal vibration. Vibration control: critical speed of shaft, vibration isolation.

Vibration of plates and membranes, modal analysis, Wave and Euler equations, numerical methods.

References

1.	Rao, J.S. and Gupta, K., Introductory Course on Theory and Practice of Mechanical Vibration, New Age International Pvt. Ltd., 2004.
2.	William T Thomson., Theory of Vibration with Applications, CBS Publishers, New Delhi, 1990.
3.	Leonard Meirovitch, Fundamentals of Vibrations, McGraw Hill, ISBN 0-07-118174-1, 2001.
4.	J.P. Den Hartog, Mechanical Vibrations, Dover Publications, New York, 1934.
5.	S. Graham Kelly, Mechanical Vibrations, Schaum’s outline Series, ISBN 978-0078442667, 1996.
6.	V. Ramamurti, Mechanical Vibration Practice and Noise Control, Narosa Book Distributors Pvt. Ltd, New Delhi, ISBN: 978-8184871999, 2012.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	State the single degree of freedom systems.
CO2	Sketch the impulse response for a periodic excitation.
CO3	Examine the concept of forced vibration.
CO4	Extend the concept to two degree of freedom systems.
CO5	Manipulate the vibration of continuous systems.

Programme Elective (PE) Courses – 3/3

Stream III (Industrial and Manufacturing Engineering)

Sl. No.	Course Code	Course Title	Credits
1.	**MEPE32**	Industrial Safety Engineering	3
2.	**MEPE41**	Mechatronics	3
3.	**MEPE44**	Additive Manufacturing	3
4.	**MEPE45**	Industrial Tribology	3
5.	**MEPE53**	Operations Research	3
6.	**MEPE73**	Fundamentals of Robotics	3
7.	**MEPE78**	Advanced Automotive Technology	3
8.	**MEPE81**	Quality Control	3

Course Code	**:**	MEPE32
Course Title	**:**	**Industrial Safety Engineering**
Type of Course	**:**	Programme Elective (PE) (Stream III)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

The objective of the course is to imbibe knowledge on

CLO1	Effective Safety management system and BBS
CLO2	Accident reporting & investigation procedure
CLO3	Workplace, physical and chemical hazards
CLO4	Occupational physiological requirement of jobs.
CLO5	Fire safety and firefighting equipment

Course Content

Evolution of modern safety concept- Behaviour Based Safety (BBS) -Safety Culture-Effective Safety management system -Safety training.

Concept of an accident, reportable and non-reportable accidents, reporting to statutory authorities-principles of accident prevention – accident investigation and analysis– unsafe act and condition – Accident Causation Theories

Workplace Hazards - Machine Guarding, guarding of hazards, Machine Guarding types and its application – Safety in welding and Gas cutting – Safety in Manual and Mechanical material handling- Safety in use of electricity

Occupational Hygiene - Chemical Hazards-Airborne particulate matters- TLV-Occupational Diseases-Physical hazards and its effects – Evaluation and control measures.

Occupational physiology-Man as a system component – allocation of functions – efficiency – occupational work capacity – aerobic and anaerobic work – evaluation of physiological requirements of jobs – parameters of measurements – categorization of job heaviness –fatigue – rest pauses.

Fire triangle- Types of fire - first aid firefighting equipment – flammability limit- LPG safety - Hazard identification and Risk Analysis.
Overview of factories act 1948 – ISO-45001

References

1.	N.S.C., 1982. *Accident Prevention Manual for Industrial Operations*. Chicago: N.S.C.
2.	Blake, R.B., 1973. *Industrial Safety*. New Jersey: Prentice Hall, Inc..
3.	Heinrich, H.W., 1980. *Industrial Accident Prevention*. New York: McGraw-Hill Company.
4.	Krishnan, N.V., 1997. *Safety Management in Industry*. Bombay: Jaico Publishing House.
5.	Ridley, J., 1983. *Safety at Work*. London: Butterworth & Co.
6.	Deshmukh, L.M., 2017. *Industrial Safety Management*. New Delhi: Tata McGraw-Hill Education.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply principles of safety management, its functions and technique in any organization
CO2	Classify and categorize the factors contributing to various hazards
CO3	Formulate accident investigation program in an organization, practice and develop accident reporting system within an organization
CO4	Apply material handling and machine guarding principles in industrial applications
CO5	Identify and analysis physical and chemical hazards and its control measures

Course Code	:	MEPE41
Course Title	:	**Mechatronics**
Type of Course	:	Programme Elective (PE) (Stream III)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize students with mechatronic systems and its key elements
CLO2	To make students learn and analyze about different sensors, signal acquisition and different filtering techniques
CLO3	To make students learn and solve the responses of different engineering systems
CLO4	To make students design systems using graphical and frequency response techniques
CLO5	To make students learn the basics of microcontrollers, microprocessors and PLCs

Course Content

Introduction to mechatronics: Definition, key elements of a mechatronic system, examples of mechatronic systems, overview of the functioning of a mechatronic system

Sensors and transducers: Performance terminology, measurement of position and speed, stress and strain, temperature, flow, vibration, acceleration, signal acquisition and data acquisition systems

System models: Actuation systems, mathematical modeling of engineering systems, dynamic responses of systems

System analysis: Analysis and design of a system using root locus and frequency response techniques

Microcontrollers and microprocessors: Interfacing microcontrollers with sensors and actuators, programmable logic controllers (PLC)

References

1.	Bolton, W., *Mechatronics- Electronic control systems in Mechanical and Electrical Engineering*, Pearson Education, 2023
2.	Alciatore, D.G., and Histand, M.B., *Introduction to Mechatronics and Measurement Sytems*, McGraw Hill Education, 2017
3.	Onwubolu, G., *Mechatronics – Principles and Applications*, Butterworth – Heinemann, 2005
4.	Bishop, R.H., *The Mechatronics Handbook*, Taylor and Francis, 2007
5.	Bell, D.A., *Electronic Instrumentation and Measurements*, Oxford University Press, 2013
6.	Sawhney, A.K., *A Course in Electrical and Electronics Measurements and Instrumentation*, Dhanpat Rai and Co., 2021
7.	Doebelin, E.O., and Manik, D.N., *Doebelin's Measurement Systems*, McGraw Hill Education, 2019
8.	Nise, N.S., *Control Systems Engineering*, Wiley, 2009
9.	Ogata, K., *Modern Control Engineering*, Pearson Education, 2015

Course Outcomes (CO)

At the end of the course student will be able

CO1	To state or give a presentation on different mechatronic systems
CO2	To analyze and solve signal conditioning circuits for a process or system
CO3	To derive the governing equations for a system in both time and frequency domains
CO4	To design controllers using root locus and frequency response methods
CO5	To state and write briefly about microcontrollers

Course Code	**:**	MEPE44
Course Title	**:**	**Additive Manufacturing**
Type of Course	**:**	Programme Elective (PE) (Stream III)
Prerequisites	**:**	Manufacturing Technology (MEPC13)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

To imbibe knowledge on

CLO1	Development of Additive Manufacturing (AM) and opportunities for product development
CLO2	Acquaint with software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.
CLO3	Familiarize with VAT polymerization and material extrusion processes, powder bed fusion and direct energy deposition.
CLO4	Applications of binder jetting, material jetting and laminated object manufacturing processes
CLO5	Analyse intellectual property, business opportunities, and future trends in emerging Additive Manufacturing applications.

Course Content

INTRODUCTION: Overview – Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping, Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain-Classification – Benefits. Applications: Building Printing-Bio Printing- Food Printing-Printing Electronics. Business Opportunities and Future Directions. Introduction to reverse engineering.

DESIGN FOR ADDITIVE MANUFACTURING (DFAM): Concepts and Objectives- AM Unique Capabilities: -Topology Optimization - DFAM for Part Quality Improvement. CAD Model Preparation - Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation. Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects, transformation.

VAT POLYMERIZATION AND MATERIAL EXTRUSION: Photo polymerization: Stereolithography Apparatus (SLA)- Materials -Process –Advantages and Limitations- Applications. Digital Light Processing (DLP) - Materials – Process - Advantages - Applications. Extrusion Based System: Fused Deposition Modeling (FDM)- Process- Materials - Applications and Limitations.

POWDER BED FUSION AND DIRECT ENERGY DEPOSITION: Powder Bed Fusion: Selective Laser Sintering (SLS): Process – Powder Fusion Mechanism – Process Parameters – Typical Materials and Application. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Process -Advantages and Applications. Beam Deposition Process: Laser Engineered Net Shaping (LENS)- Process -Material Delivery - Process Parameters -Materials -Benefits -Applications.

OTHER ADDITIVE MANUFACTURING PROCESSES: Binder Jetting: Three-Dimensional Printing - Materials -Process - Benefits and Limitations. Material Jetting: Multijet Modeling- Materials - Process - Benefits. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials-Application and Limitation.

References

1.	Andreas Gebhardt and Jan-Steffen Hötter “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications, United States, 2015.
2.	Ian Gibson, David W. Rosen and Brent Stucker “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, 2nd edition, Springer., United States, 2015.
3.	K.R. Balasubramanian and V. Senthilkumar “Additive Manufacturing Applications for Metals and Composites”, IGI Global publishing, United States, 2020.
4.	Amit Bandyopadhyay and Susmita Bose, “Additive Manufacturing”, 1st Edition, CRC Press., United States, 2015.
5.	Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing”, Hanser Gardner Publication, Cincinnati., Ohio, 2011.
6.	Chua, C K, Leong, K F and Lim CS, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Recognize the development of AM technology and opportunities for transforming a concept into a model.
CO2	Proficiently use software’s to create physical objects for product development.
CO3	Elaborate the vat polymerization and material extrusion processes and its applications.
CO4	Acquire knowledge on process and applications of powder bed fusion and direct energy deposition.
CO5	Evaluate the advantages, limitations, applications of binder jetting, material jetting and laminated object manufacturing processes.

Course Code	:	MEPE45
Course Title	:	**Industrial Tribology**
Type of Course	:	Programme Elective (PE) (Stream III)
Prerequisites	:	Engineering Materials (MEPC18)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize students with tribological concepts and phenomena
CLO2	To make students learn and analyze different types of friction and measurement techniques
CLO3	To make students learn different wear models and controlling techniques
CLO4	To make students learn about lubrication and coating to reduce wear
CLO5	To make students learn the basics of surface topography measurements

Course Content

Tribology -- definition, Industrial significance, economic aspects, trends. Factors influencing Tribological phenomena. Engineering surfaces - Surface characterization, Computation of surface parameters.

Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction. Stick-slip friction behavior, frictional heating and temperature rise. Friction measurement techniques.

Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques.

Introduction to lubrication. Lubrication regimes. Introduction to micro and nano tribology. Coating characteristics, Coating performance evaluation, Powder coatings and types, application methods.

Surface topography measurements - Electron microscope and friction and wear measurements - Laser method. Sliding friction and wear abrasion test, rolling contact and fatigue test, solid particle and erosion test, Use of transducers and instruments in Tribology

References

1.	Halling J., *Principles of Tribology*, Palgrave Macmillan, 1978
2.	Williams J.A., Engineering Tribology, Oxford University Press, 1994
3.	Neale M.J., *The Tribology Handbook*, Butterworth-Heinemann Ltd, 1995
4.	Hutchings I., and Shipway P., *Tribology: Friction and Wear of Engineering Materials*, Butterworth-Heinemann Ltd., 2017
5.	Stachowiak G. W., and Batchelor A. W., *Engineering Tribology*, Butterworth-Heinemann Ltd., 2020
6.	Ludema K.C., and Ajayi O.O., *Friction, Wear, Lubrication: A Textbook in Tribology*, CRC Press, 2018.
7.	Bhushan, B., "*Nanotribology and Nanomechanics: An Introduction*", Springer International Publishing AG, 2018

Course Outcomes (CO)

At the end of the course student will be able

CO1	To state or give a presentation on the state-of-the-art of tribology, applications and industrial significance
CO2	To state or write the different types of friction, stick-slip phenomena and techniques of measuring friction
CO3	To state or write the different wear models and methods of controlling wear
CO4	To state or write about lubrication and coating in tribology to reduce friction
CO5	To state or write briefly about surface topography measurements

Course Code	**:**	MEPE53
Course Title	**:**	**Operations Research**
Type of Course	**:**	Programme Elective (PE) (Stream III)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

The objectives of this course is to imbibe knowledge on,

CLO1	Using optimization techniques for solving engineering problems
CLO2	Different optimization models adopted in engineering industry
CLO3	Understanding and applying solution algorithms for various types of Operations Research models
CLO4	Analyzing real-life situations where stochastic models are applicable and understanding how to interpret the results
CLO5	Developing problem-solving skills that can be adapted to new and evolving challenges across various industries

Course Content

INTRODUCTION

Historical evolution of Operations Research, Importance of OR in decision making Processes. Linear programming – Introduction to Linear Programming and Its applications. Graphical Method – Simplex algorithm – Step-by-Step Procedure for solving LP problems Using Simplex. Duality formulation – Economic Interpretation of dual variables. Sensitivity analysis.

TRANSPORTATION AND ASSIGNMENT MODELS

Transportation Models: Applications in Supply Chain and Logistics, Mathematical Formulation of Transportation Problems, Methods for Solving Transportation Problems.

Assignment models: Mathematical formulation, solution methods

Traveling Salesman problem – Networks models – Shortest route – Minimal spanning tree - CPM and PERT networks – Critical path scheduling,

INVENTORY MANAGEMENT

Inventory models – Types of Inventories – Economic order quantity (EOQ) models – EOQ models with and without shortage - Quantity discount models – Stochastic inventory models – Multi product models

QUEUING THEORY

Queueing models – Single server and multi-server models. Poisson input – Exponential service – Constant rate service - Infinite population

DECISION MODELS AND GAME THEORY

Decision models – Introduction to Game theory – Basic Concepts and Terminology. Minimax (Maxmin) criterion and optimal strategy, Saddle point, Solutions of games with pure strategy – Games with mixed strategy – 2x2 games - Linear programming solution – Replacement models – Models based on service life – Economic life – Single / Multi variable search technique – Dynamic Programming.

References

1.	Taha, H.A., 2013. *Operations research: an introduction*. Pearson Education India.
2.	Shennoy, G.V. & Srivastava, U.K., 1994**.** *Operation Research for Management*. Wiley Eastern.
3.	Bazara, M.S. and Jarvis, J.J., 1990. *Linear programming and network flows*. Wiley.
4.	Philip, D.T. and Ravindran, A., 1992. Operations Research. John Wiley.
5.	Hillier, F.S. and Lieberman, G.J., 1986. *Operations Research*. Holden Day.
6.	Budnick, F.S., Mojena, R. and Vollmann, T.E., 1990. Principles of operations research for management.
7.	Tulsian, P. and Pasdey, V., 2002. *Quantitative Techniques*. Pearson Asia.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To formulate mathematical models for complex real-world problems.
CO2	To apply linear programming methods, such as Simplex algorithm to solve optimization problems
CO3	To analyze transportation and assignment problems and determine optimal solutions
CO4	To analyze and solve queuing models, including single-server and multi-server systems.
CO5	To utilize game theory to analyze strategic interactions and decision-making in both competitive and cooperative environments.

Course Code	:	MEPE73
Course Title	:	**Fundamentals of Robotics**
Type of Course	:	Programme Elective (PE) (Stream III)
Prerequisites	:	Mechanics of Machines – I (MEPC17)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize students with different kinds of robots and their applications in present day word
CLO2	To make students derive and solve the kinematic and dynamic equations of motion of manipulators
CLO3	To make students learn and comprehend the concepts of Jacobian and manipulability
CLO4	To make students learn and implement linear and nonlinear control of robot manipulators
CLO5	To make students learn about the basics of robot sensing and vision

Course Content

Definition and classification of robots and manipulators: Introduction, history and types of robots, need and application, overview of the functioning of a robot

Robot arm kinematics: Joint types, degrees of freedom, homogeneous transformation, Denavit-Hartenberg (DH) respresentation, direct and inverse kinematics

Robot arm dynamics: Lagrange-Euler formulation, Newton-Euler formulation, velocity propagation along links, manipulator Jacobian and singularities, manipulator trajectory planning

Control of robot manipulators: Position control of second order systems, control law partitioning, Lyapunov stability analysis, force control of manipulators

Sensing and vision: Range sensing, proximity sensing, touch sensors, force and torque sensors, image acquisition, image representation, image processing

References

1.	Fu K.S., Gonzalez R.C. and Lee C.S.G., *Robotics: Control, Sensing, Vision and Intelligence*, McGraw Hill Education (India) Private Limited, 2017
2.	Craig J.J., *Introduction to Robotics – Mechanics and Control*, Pearson Education, 2017
3.	Mittal R.K. and Nagrath I.J., *Robotics and Control,* McGraw Hill Education (India) Private Limited, 2017
4.	Saha. S.K., *Introduction to Robotics*, McGraw Hill Education (India) Private Limited, 2014
5.	Ghosal A. Robotics: *Fundamental Concepts and Analysis*, Oxford University Press, 2006
6.	Lynch K.M. and Park F.C. *Modern Robotics: Mechanics, Planning and Control,* Cambridge University Press, 2017

Course Outcomes (CO)

At the end of the course student will be able

CO1	To state or give a presentation on the state-of-the-art of robotics technology, applications and need for robots
CO2	To derive and solve the dynamic equations of motion of a manipulator
CO3	To identify the singular configuration of manipulators
CO4	To apply the control laws for trajectory tracking of the robots
CO5	To state and write briefly about robotic sensors and vision

Course Code	**:**	MEPE78
Course Title	**:**	**Advanced Automotive Technology**
Type of Course	**:**	Programme Elective (PE) (Stream III)
Prerequisites	**:**	Automobile Engineering (MEPC23)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an in-depth understanding of cutting-edge technologies in the automotive industry.
CLO2	To explore advanced powertrain systems, including electric and hybrid vehicles.
CLO3	To analyse vehicle dynamics, stability, and control systems for enhanced safety and performance.
CLO4	To examine the role of advanced materials and manufacturing processes in automotive engineering.
CLO5	To study the impact of autonomous and connected vehicle technologies on future automotive trends.

Course Content

Advanced Powertrain Technologies:
Internal Combustion Engine (ICE) Advancements - High-efficiency combustion strategies - Advanced turbocharging and direct fuel injection systems.
Emission control technologies: SCR, GDI, and EGR systems. Electric and Hybrid Powertrains - Design and operation of electric motors and controllers. Energy storage systems: Batteries, supercapacitors, and fuel cells. Hybrid vehicle configurations and regenerative braking.

Vehicle Dynamics and Control Systems:
Advanced Vehicle Dynamics - Detailed analysis of vehicle handling and stability. Active suspension systems and their control strategies. Tire modelling and performance in dynamic conditions. Control Systems: Advanced braking technologies: ABS, EBD, ESC. Steer-by-wire and drive-by-wire systems. Integration of ADAS (Advanced Driver Assistance Systems).

Advanced Materials and Manufacturing Techniques:
Materials in Automotive Engineering - Lightweight materials: Composites, high-strength steels, and aluminum alloys. Application of carbon fiber in structural components. Nanotechnology in automotive materials. Advanced Manufacturing Processes: Additive manufacturing and its automotive applications. Precision machining and forming techniques. Surface treatment and coating technologies.

Autonomous and Connected Vehicles:
Autonomous Vehicle Technologies: Sensor technologies: LiDAR, RADAR, and computer vision. Autonomous navigation and decision-making algorithms. Real-time vehicle communication and V2X technology. Connected Vehicles: Vehicle-to-Everything (V2X) communication systems. Telematics and connected services. Cybersecurity challenges in connected vehicles.

Sustainable and Future Automotive Technologies:
Sustainable Automotive Solutions - Development of alternative fuels and propulsion systems. Life cycle analysis and sustainability in automotive design. Recycling and end-of-life vehicle management. Future Trends: The rise of shared mobility and its impact on vehicle design. Integration of smart city technologies with automotive systems. Emerging trends in vehicle electrification and automation.

References

1.	David Crolla, Automotive Engineering: Powertrain, Chassis System and Vehicle Body, Butterworth-Heinemann Ltd; Illustrated edition, 2009
2.	James Larminie, John Lowry, Electric Vehicle Technology Explained, 2nd Edition, WILEY, 2012
3.	Iqbal Husain, Electric and Hybrid Vehicles Design Fundamentals, CRC Press, 2021
4.	Rajesh Rajamani, Vehicle Dynamics and Control, 2nd Edition, Springer New York, NY, 2011.
5.	Reza N. Jazar, Vehicle Dynamics: Theory and Applications, Springer, 2017.
6.	Heinz Heisler, Advanced Vehicle Technology, 2nd Edition, Butterworth-Heinemann, Elsevier 2002
7.	Jason Rowe, Advanced Materials in Automotive Engineering, Reprint edition, Woodhead Publishing Ltd., 2016
8.	Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach, WILEY, 2014.
9.	Navet N, Automotive Embedded Systems Handbook- Industrial Information Technology Series, CRC Press, Taylor & Francis, 2000
10.	Uwe Kiencke, Lars Nielsen, Automotive Control Systems for Engine, Driveline, and Vehicle, 2nd Edition, Springer, 2005

Course Outcomes (CO)

At the end of the course student will be able

CO1	To know the suitable control system for different electrical vehicles application.
CO2	To possess the knowledge about various alternative energy systems and fuel cells.
CO3	To identify various modern features for better functioning of vehicle.
CO4	To demonstrate various safety features and equipment used in modern vehicle
CO5	To apply the fundamental knowledge in developing modern vehicle systems.

Course Code	**:**	MEPE81
Course Title	**:**	**Quality Control**
Type of Course	**:**	Programme Elective (PE) (Stream III)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

The objectives of this course is to imbibe knowledge on,

CLO1	Applying tools for continuous quality improvement, including the use of Pareto Diagrams to prioritize key areas for process enhancement.
CLO2	Comparing various quality control philosophies and their application in quality management systems.
CLO3	Fundamental statistical concepts, including probability distributions, inferential statistics, and data analysis techniques.
CLO4	Basics of statistical process control, including the use of control charts for variables and attributes
CLO5	Product and process design concepts, with a focus on reliability, experimental design, and the Taguchi method for optimizing quality.

Course Content

INTRODUCTION TO QUALITY CONTROL AND TOTAL QUALITY SYSTEM

Introduction to quality control and total quality system- Historical evolution, key concepts and principles, Components of TQS. Philosophies of quality control-Deming's philosophy, Crosby's philosophy, Juran's philosophy. Quality Control, Quality assurance and Quality Management

TOOLS FOR CONTINUOUS QUALITY IMPROVEMENT

Tools for continuous quality improvement: Pareto Diagrams, Flow charts, Cause effect diagrams, scatter plots, Multivariable charts, Failure Mode, effects and criticality analysis (FMECA), Control Charts, Histogram, Run Charts.

STATISTICAL FOUNDATIONS AND DATA ANALYSIS

Statistical foundations Review: Population and sample, Probability, Normal, Poisson, binomial, Hypergeometric distributions, Inferential statistics- Estimation, Hypothesis Testing, Sampling techniques

Data analysis and sampling, validating distribution assumptions, transformation to achieve normality, analysis of count data, concepts of sampling.

Exploratory Data Analysis (EDA), Regression Analysis- Simple and multiple linear regression, Correlation Analysis- Pearson and Spearman correlation coefficients, Bayesian Statistics

STATISTICAL PROCESS CONTROL

Basics of Control charts, Control charts of variables- X-bar and R Charts X-bar and S Charts Individual/moving range (I-MR) Charts. Control charts for attributes- P Charts, NP Charts, C Charts. Process capability analysis- Cp and Cpk Indices, Pp and Ppk Indices, Acceptance sampling plans. Control Chart Design and Implementation, Linking Control Charts with Process Improvement

PRODUCT/PROCESS DESIGN AND RELIABILITY

Reliability: Definition and Importance**.** Reliability Metrics-Mean Time To Failure (MTTF), Mean Time Between Failures (MTBF), Failure Rate, Reliability Function and Hazard Rate. Reliability Modeling- Survival Analysis, Reliability Testing.

Experimental Design - Fundamentals of Experimental Design, Design of experiments (DoE). Types of Experimental Designs - Factorial Designs, Response Surface Methodology (RSM), Blocking and Randomization. Taguchi Method - Reliability Centered Maintenance (RCM).

References

1.	Mitra, A., 2016. Fundamentals of quality control and improvement. John Wiley & Sons.
2.	Croby, Philip B., 2001, Quality Without Tears, New York, McGraw Hill Book Company
3.	Oakland, S.J., 2000. TQM. Butterworth-Heinemann
4.	Kanishka Bedi, 2008, Quality Management, Oxford University Press, New Delhi.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To articulate the principles of quality control and total quality systems, including the implementation of quality management frameworks
CO2	To demonstrate the ability to use quality improvement tools such as Pareto diagrams.
CO3	To apply fundamental statistical concepts, including population and sample, probability distributions, and inferential statistics
CO4	To develop skills in using statistical process control techniques, including control charts for variables and attributes
CO5	To apply principles of reliability engineering, experimental design, and the Taguchi method to design and optimize products

Open Elective (OE) Courses

Sl. No.	Course Code	Course Title	Credits
1.	**MEOE10**	Smart Materials and Structures	3
2.	**MEOE11**	Optimization in Engineering Design	3
3.	**MEOE12**	Energy Conservation and Management	3
4.	**MEOE13**	Energy Storage Technology	3
5.	**MEOE14**	Low Temperature Technology	3
6.	**MEOE15**	Waste to Energy Conversion Techniques	3
7.	**MEOE16**	Non-Destructive Testing	3
8.	**MEOE17**	Pollution and Control	3
9.	**MEOE18**	Welding Technology	3
10.	**MEOE19**	Finite Element Method for Engineers	3
11.	**MEOE20**	Computational Methods in Engineering	3
12.	**MEOE21**	Elementary Continuum Mechanics	3
13.	**MEOE22**	Modern Automotive Technology	3
14.	**MEOE23**	Hydrogen – Production Handling and Storage	3
15.	**MEOE24**	Engineering Product Realization	3

Course Code	**:**	MEOE10
Course Title	**:**	**Smart Materials and Structures**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the interdisciplinary material properties for sensors and actuators applications.
CLO2	To familiarize the working principles of various sensors for different applications.
CLO3	To demonstrate the role of actuators and actuator materials.
CLO4	To introduce the basic concepts of piezoelectric energy harvesting.
CLO5	To discuss the various measurements and signal processing techniques for structural dynamic applications

Course Content

Introduction to Smart Materials, Structures and Products Technologies - Smart materials (Physical Properties) Piezoelectric Materials, Elecrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials, Magnetorheological Fluids, Electrorheological Fluids, Shape Memory Materials.

Smart Sensors and Technologies - Smart Sensors: Accelerometers - Force Sensors-Load Cells, Torque Sensors, Pressure Sensors, Microphones, Impact Hammers-MEMS Sensors – Fiber Optic Sensors.

Smart Actuator and its Techniques – Role of Actuators and Actuator materials – Piezoelectric and Electrostrictive Materials – Magneto-structural Materials – Shape Memory Alloys – Electro rheological fluids – Electromagnetic actuation.

Introduction to Piezoelectric Energy harvesting - Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modelling - piezoelectric generators, Piezoelectric energy harvesting applications.

Measurement and Signal Processing Techniques – Static and Dynamic Measurement Methods- Signal conditioning devices; Structural dynamics and Identification techniques; Passive, Semi -active and Active control; Feedback and feed forward/control strategies.

References

1.	Srinivasan, A. V. and Michael McFarland, D., “Smart Structures: Analysis and Design”, Cambridge University Press, 2009.
2.	Gandhi, M. V. and Thompson B.S., “Smart Materials and Structures” Chapman and Hall, London, 1992.
3.	Michelle Addington and Daniel L. Schodek, “Smart Materials and Technologies: For the Architecture and Design Professions”, Routledge 2004.
4.	Brain Culshaw, “Smart Structure and Materials”, Artech House – Borton. London,1996.
5.	Gauenzi, P., “Smart Structures,” Wiley, 2009

Course Outcomes (CO)

At the end of the course student will be able

CO1	To make use of various smart materials properties for sensors and actuators applications.
CO2	To understand the working of sensors for various applications.
CO3	To identify the suitable actuators for corresponding applications.
CO4	To model the piezoelectric effect for energy harvesting.
CO5	To demonstrate the measurement and signal processing techniques for structural dynamics testing.

Course Code	:	MEOE11
Course Title	:	**Optimization in Engineering Design**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the need and origin of the optimization methods.
CLO2	Get a broader picture of the various applications of optimization methods used in engineering.
CLO3	Define an optimization problem and its various components
CLO4	Formulate optimization problems as mathematical programming problems.
CLO5	Briefly learn about classical and advanced techniques in optimizations.

Course Content

Introduction to optimization. Classical optimization techniques. Single variable optimization, Unconstrained multivariable optimization.

Nonlinear programming: equality constraint, KKT conditions
Numerical optimization: Region elimination techniques, Fibonacci Method, Golden Section Method, Interpolation Methods

Unconstrained optimization techniques: Direct and indirect search method, Nonlinear programming: constrained optimization techniques, **Introduction to Geometric and integer Programming** Constrained Geometric Programming Problem

Nontraditional algorithms: Introduction and Principles of Evolutionary Computation (EC), Binary-Coded Genetic (BCGA), Differential Evolution (DE), Particle Swarm Optimization (PSO).

Introduction to Multi-Objective Optimization: Introduction, Generalized Formulation, Concept of Dominance and Pareto-optimality, Graphical Examples, Terminologies.

References

1.	Rao, Singiresu S. “Engineering optimization: theory and practice.” John Wiley & Sons, 2019.
2.	Deb, Kalyanmoy. “Optimization for engineering design: Algorithms and examples”. PHI Learning Pvt. Ltd., 2012.
3.	Chong EK, Żak SH. “An introduction to optimization”. John Wiley & Sons; 2013
4.	Nocedal, Jorge, and Wright, Stephen. Numerical “Optimization. Germany”, Springer New York, 2006.
5.	Belegundu, Ashok D., and Chandrupatla, Tirupathi R.. “Optimization Concepts and Applications in Engineering”. India, Cambridge University Press, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Enumerate the necessity of optimization in engineering design.
CO2	Identify the various optimization techniques pertaining to design-oriented problems.
CO3	Solve problems with single and multi – variable.
CO4	Distinguish between integer and geometric specialized algorithm
CO5	Apply non-traditional algorithms for optimization of typical problems requiring their application.

Course Code	**:**	MEOE12
Course Title	**:**	**Energy Conservation and Management**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the present energy scenario and the need for energy conservation
CLO2	To understand the monitoring / targeting aspects of Energy
CLO3	To study the different measures for energy conservation of various thermal energy systems
CLO4	To learn economic analysis and project planning on energy conservation
CLO5	To understand the energy conservation principle with electrical equipment

Course Content

Energy Scenario - Basics of Energy and its various forms - Energy Management and Audit - Material and Energy Balance -Energy Action Planning-Financial Management -Project Management -Energy Monitoring and Targeting -Global Environmental Concerns

Energy Efficiency in Thermal Utilities - Fuels and Combustion-Boilers-Steam System-Furnaces - Insulation and Refractory -FBC Boilers -Cogeneration -Waste heat recovery

Energy Efficiency in Electrical Utilities-Electrical Systems-Electric Motors-Compressed Air System-HVAC and Refrigeration System-Fans and Blowers-Pumps and Pumping System. Cooling Tower-Lighting System-Diesel Generating System-Energy Efficient Technologies in Electrical Systems

Energy Performance Assessment for Equipment and Utility systems -Boilers-Furnaces Cogeneration, Turbines (Gas, Steam)- Heat Exchangers-Electric Motors and Variable Speed Drives-Fans and Blowers-Water Pumps-Compressors

HVAC Systems-Lighting Systems-Performing Financial Analysis-Applications of Non-Conventional and Renewable Energy Sources-Waste Minimization and Resource Conservation.

References

1.	Guidebook for National Certification Examination for Energy Managers and Energy Auditors, Bureau of energy efficiencies, 2005.
2.	Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980
3.	Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1988
4.	Reay D.A, Industrial Energy Conservation, 1st edition, Pergamon Press, 1977.
5.	Mehmet Kanoğlu, Yunus A. Çengel, Energy Efficiency and Management for Engineers, 1st Edition, McGraw-Hill Education, 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply energy conservation principles for practical devices
CO2	Assess the performance and energy efficiency of various thermal energy systems
CO3	Evaluate the energy loss with various electrical equipment
CO4	Perform energy audit in thermal and electrical systems
CO5	Execute techno-economic analysis and project planning on energy conservation

Course Code	:	MEOE13
Course Title	:	**Energy Storage Technology**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the Need and Scope of Energy Storage Systems
CLO2	To analyse Thermal Energy Storage Systems.
CLO3	To evaluate Chemical Energy Storage Solutions
CLO4	To design and Optimize Battery Systems for Transportation.
CLO5	To master Electrochemical Storage Technologies

Course Content

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications

Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of Transys

Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc - Air (ii) Nickel Hydride, (iii) Lithium Battery

Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis –advantage and drawback of each type.

Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications

References

1.	Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002
2.	Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
3.	Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012
4.	Charles R. Russell, Elements of Energy Conversion, Permagon Press, 1967.
5.	Hart A.B. and Womack, G.J., Fuel Cells: Theory and Application, Prentice Hall, 1989.

Course outcomes

At the end of the course student will be able to

CO1	Understand the necessity and various types of energy storage technologies, and effectively compare their applications and efficiency
CO2	Analyze and model thermal energy storage systems, including water, rock bed, and phase change storage units.
CO3	Comprehend the fundamental concepts of batteries, including performance measurement, charging/discharging processes, and safety considerations.
CO4	Explain the principles and types of fuel cells, assess their advantages and drawbacks, and conduct a detailed analysis of electrochemical storage systems
CO5	Understand the principles, methods, and applications of advanced energy storage technologies, including flywheels, super capacitors, and compressed air energy storage, as well as the concept and applications of hybrid storage systems

Course Code	:	MEOE14
Course Title	:	**Low Temperature Technology**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamental principles of refrigeration, air conditioning and cryogenics.
CLO2	To select the right insulation for a particular cooling application
CLO3	To understand the behavior of properties of materials at different low temperatures
CLO4	To Select the cooling system for any given application and human comfort
CLO5	To Evaluate the merits of cooling systems and their usage

Course Content

Basics of thermodynamic processes, Introduction to refrigeration, air conditioning and cryogenics.

Refrigeration, Vapor compression systems: Ideal and actual cycles, Vapor absorption systems: Refrigerant – absorbent combinations.

Psychrometry – Definitions for properties. Introduction to cooling load calculations. Comfort conditions. Air-conditioning systems.

Cryogenic fluids, properties, behavior of cryogenics fluids, storage of cryogenic fluids, Properties of materials at cryogenic temperatures, Insulation techniques, different types, vacuum techniques.

References

1.	Arora, R.C., Refrigeration and Air Conditioning, PHI Pvt Ltd, 2010
2.	Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
3.	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
4.	Herald Weinstock, Cryogenic Technology, 1969.
5.	Roy.J Dossat, Principles of Refrigeration, Pearson Education, 4th Edition , 2006

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Elucidate and implement the principles of refrigeration, air conditioning, and cryogenics.
CO2	Comprehend the characteristics of materials at reduced temperatures.
CO3	Utilize various insulation and vacuum techniques for low-temperature systems.
CO4	Choose the appropriate cooling system for a specific application and human comfort.
CO5	Assess the advantages of various cooling systems and their applications.

Course Code	**:**	MEOE15
Course Title	**:**	**Waste to Energy Conversion Techniques**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand bioenergy and in particular the exploitation of biomass
CLO2	To study the thermochemical Conversion processes (gasification, pyrolysis)
CLO3	To distinguish the factors influencing biofuels/energy-related environmental, economic, & social issues.
CLO4	To study the impacts of biofuel utilization and application.
CLO5	Life cycle analysis and assessment on biofuel Production.

Course Content

Introduction to energy from waste- Chemical composition, properties of biomass – Energy plantations, Size reduction, Briquetting, Drying, Storage, and handling of biomass.

Thermo-chemical conversion of lignocellulose biomass, Thermochemical principles: Combustion, Chemistry of gasification, types, comparison, Pyrolysis - Classification, Incineration, process governing parameters and Typical yield rates, Mathematical model, Energy and Economic analysis using Aspen plus.

Biochemical conversion of biomass to alcohol, Biodiesel production from oilseeds, waste oils, and algae, Fischer tropsch synthesis, gas to liquid conversion technologies.

Combustion of biomass and cogeneration systems, combustion of woody biomass, theory calculation and design of equipment, fuel cell, gas turbine, Electricity generation, case studies.

Role of energy in economic development and social transformation. Energy Consumption in various sectors and its changing patterns Life Cycle Analysis of biofuels, Techno-economic features of bio-fuels, Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle, Costing.

References

1.	D.L. Klass and G.M. Emert, Fuels from Biomass and Wastes, Ann Arbor Science publ.Inc. Michigan, 1985.com
2.	Chakraverthy A, “Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes”, Oxford & IBH publishing Co, 1989.
3.	Rezaiyan. J and N. P. Cheremisinoff, “Gasification Technologies, A Primer for Engineers and Scientists”, Taylor & Francis, 2005.
4.	Mann MK, Spath PL. Life cycle assessment of a biomass gasification combined-cycle power system. National Renewable Energy Lab., Golden, CO (US); 1997 Dec 1.
5.	Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store. 2019

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Characterization techniques of the biomass and Effective utilization of biomass from Wastes
CO2	Practical knowledge of Thermochemical conversion techniques.
CO3	Power generation from bioenergy and the applications.
CO4	Understand the role of bio energy and its impact in economic and social development.
CO5	Techno-economic analysis of thermochemical conversion and LCA assessment

Course Code	**:**	MEOE16
Course Title	**:**	**Non-Destructive Testing**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To have a basic knowledge of surface NDE techniques which enables to carry out various inspection in accordance with the established procedures.
CLO2	To study the codes, standards or specifications related to each testing method.
CLO3	To identify the types of equipment used for detecting the surface and internal flaws
CLO4	To acquire the knowledge on the selection of the suitable NDT technique for a given application
CLO5	To analyze the flaw significantly in pressure vessels and pipelines using various NDT methods.

Course Content

Overview of NDT: Introduction to destructive and non-destructive testing, Significance of testing materials, properties of engineering materials. Scope, characteristics and Limitations of NDT, Visual examination methods – Different visual examination aids.

Surface Methods: Visual Inspection – Dye/Liquid Penetrant Testing – Magnetic Particle Inspection.

Volumetric Methods: Electro-Magnetic Methods – Acoustical Methods – Radiographic Methods – Thermal Methods – Optical Methods.

Applications in Engineering Industry: Dimensional Measurement, Estimation of Mechanical and Physical properties of materials, Analysis of quality of weldments, Leak and pressure testing of pressure vessels.

References

1.	Charles, J. Hellier, "Handbook of Non-destructive evaluation", McGraw Hill, New York 2001.
2.	Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005
3.	ASM Metals Handbook Vol. 17::1989, Non-Destructive Evaluation and Quality Control, ASM International, Metals Park, Ohio, USA, ISBN-13- 978-0871700230
4.	Baldev Raj, T.Jayakumar, M.Thavasimuthu, 2011. Practical Non-Destructive Testing, Third Edtion, Narosa Publishing House, ISBN-13- 978-8173197970.
5.	J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition, 2011.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To select appropriate NDT methods for flaw detection.
CO2	To use the various Testing methods for understanding the defects and characterization of industrial components.
CO3	To perform non-destructive examinations of weldments.
CO4	To acquire the knowledge for identifying strengths and weaknesses in materials used in fabrication.
CO5	To interpret the results of various testing methods and also have the ability towards analyzing the influence of various parameters on the testing.

Course Code	**:**	MEOE17
Course Title	**:**	**Pollution and Control**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on the atmosphere and eco-legislations
CLO2	To classify air, water and land pollutants and sources
CLO3	To understand hazardous waste management
CLO4	To learn pollution sampling and analysis
CLO5	To study the various methods of controlling pollution

Course Content

Air pollution – sources, concentration and effects, Air quality management - indoor air quality. Measurement and control of air pollution - emission standards. Atmospheric dispersal of pollutants and modelling of air pollution.

Water pollution - sources of contamination - water quality and standards - chemical pollution of the aquatic environment - regulation of direct discharge - sewage treatment processes - sludge treatment and disposal. Sources and types of toxic wastes - treatment of toxic wastes - disposal of toxic wastes. Pollution in marine environment - sources, movement and behavior of pollutants.

Soil pollution and Land contamination - sources - properties - consequences of soil pollution - solid waste management - recycling and reuse. Radioactivity in environment - types of radiation - effects of radiation - radioactive waste treatments and disposal.

Noise pollution - sources and effects - Noise level measurement and analysis. Noise emission standards - Industries - Automotive. Active and Passive Noise Control.

Clean technologies - Integrated design for pollution prevention and control - case studies - Legal control of pollution – trends and issues.

References

1.	Roy M. Harrison, Pollution causes, effects and control, 4th Edition, Royal Society of Chemistry, 2001.
2.	Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.
3.	Arcadio P Sincero and G.A. Sincero, Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
4.	Mahajan, S.P., “Pollution control in process industries”, Tata McGraw Hill Publishing Company, New Delhi, 1993.
5.	Masters, G, Introduction to Environmental Engineering and Science Prentice Hall of India Pvt. Ltd, New Delhi, 2003.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the atmospheric pollutants and eco-legislations
CO2	Classify air, water and land pollutants and sources
CO3	Manage hazardous wastes in industries
CO4	Measure and Analyze various pollutants
CO5	Understand various methods of controlling pollution

Course Code	:	MEOE18
Course Title	:	**Welding Technology**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the different types of welding processes and understand the concept of weldability.
CLO2	To understand the principles of fusion welding processes.
CLO3	To acquire fundamental knowledge on principles of high energy density welding processes.
CLO4	To impart a sound understanding of principles of solid-state welding processes.
CLO5	To understand the effect of welding parameters on weld quality through modeling and optimization techniques.

Course Content

Classification of welding processes: heat sources. Weld joint design - Weldability of steels and other materials - Weld defects.

Manual Metal Arc welding, TIG / A-TIG Welding, gas metal arc welding, Submerged arc welding.

Electron beam welding, Plasma arc welding, Laser beam welding - advantages and limitations, process variables and their effects.

Friction welding and Friction stir welding processes – effects of speed and pressure – Explosive welding –Process Parameters – Resistance Welding – types and process capabilities.

Cold pressure welding - Ultrasonic welding - Recent Advances in welding - Modeling and optimization of welding process.

References

1.	Parmar, R.S., “Welding Engineering and Technology”, Khanna Publishers, 2013, ISBN-13- 978-8174090287.
2.	Lancaster J.F, ‘The Physics of Welding: International Institute of Welding’, Pergamon Press, 2013, ISBN-13- 978-0080340760
3.	AWS, " Welding Handbook ", Vol. I to V. 1976
4.	Weman, K., “Welding Processes Handbook”, Woodhead Publishing, 2011, ISBN-13- 978-0857095107
5.	Nadkarni S.V., ‘Modern Arc Welding Technology’, Ador Welding Ltd., 2008. ISBN-13- 9788120416765

Course Outcomes (CO)

At the end of the course student will be able

CO1	To learn basic principles and methods utilized for testing weldability.
CO2	To understand the impact of welding operations on environment and need for sustainable development
CO3	To select a suitable welding process for a particular application.
CO4	To acquire knowledge on modern developments in welding techniques.
CO5	To get the knowledge about newly developed welding process and its parameters.

Course Code	:	MEOE19
Course Title	:	**Finite Element Method for Engineers**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize with Galerkin's method and derive weak form of governing differential equation.
CLO2	To understand the finite element method for 1-D problems.
CLO3	To acquaint with the FE solution of advanced problems involving 2-D and 3-D structures.
CLO4	To understand the Gauss-Quadrature technique for numerical integration.
CLO5	To apply FEM for dynamics problems in structural mechanics.

Course Content

Introduction – Illustration using spring systems and simple problems, Weighted residual methods – Galerkin's method, Variational approach, Rayleigh-Ritz method.

1-D finite element analysis: truss element, beam element, frame element, Heat transfer problems.

2-D finite element analysis: types of elements, shape functions, natural coordinate systems. Applications to structural mechanics – Plane stress element, plane strain element, axisymmetric element, plate bending element.

Numerical integration – Solution of finite element equations. 3-D finite element analysis: Solid elements.

Dynamics problems in structural mechanics, Fluid flow problems, Error analysis and convergence.

References

1.	Zienkiewicz, O.C. and Taylor, R.L., 2005. The finite element method set. Elsevier.
2.	Bathe, K.J., 2014. Finite element procedures. Prentice Hall.
3.	Reddy, J.N., 2005. An introduction to the finite element method. New York: McGraw-Hill.
4.	Hughes, T.J.R., 2000. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis. Dover Publications.
5.	Bhatti, M.A., 2005. Fundamental finite element analysis and applications: with Mathematica and Matlab computations. John Wiley & sons, Inc.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To solve Boundary Value Problems using classical methods without using FEM.
CO2	To derive the weak form of the governing differential equation and to discretize the domain using finite element method.
CO3	To solve Boundary Value Problems involving structural mechanics, fluid flow, and heat transfer in 1-D, 2-D, and 3-D.
CO4	To apply Gauss-Quadrature technique for numerical integration in both physical and natural coordinate spaces.
CO5	To solve dynamics problems in structural mechanics using FEM.

Course Code	**:**	MEOE20
Course Title	**:**	**Computational Methods in Engineering**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce various algorithms to find numerical solutions of linear system of equations and EVPs.
CLO2	Analyzing different techniques to find the roots of nonlinear equations numerically.
CLO3	To learn different methods for interpolating a function numerically.
CLO4	Finding numerical differentiation and integration of a function.
CLO5	To study appropriate numerical methods for solving ODEs and PDEs.

Course Content

Introduction: Numerical precision in digital computing and its effect on numerical calculations, Taylor series and truncation, Rounding off errors.

Numerical Solution of Linear System of Equations: Direct methods (Cramer's rule, Gauss Elimination method, pivoting, LU factorization method, Cholesky method), Iterative methods (Jacobi method, Gauss-Seidel method). Conditioning, Matrix and vector norms. **Numerical Solution of Eigen Value Problems (EVPs):** Determinant based method, Transformation based method, Vector iteration method.

Numerical Solution of Nonlinear Equations: Bracketing methods (Bisection, False-position method), Open methods (Newton-Raphson method, Secant method, Fixed-point iteration method). **Interpolation and Curve Fitting:** Lagrange methods, Newton Methods, Piecewise interpolation methods. Least square linear approximation.

Numerical Differentiation: Forward, Backward and Central difference formulas. Extrapolation technique. **Numerical Integration:** Newton-Cotes rules (Trapezoidal rule, Simpson's rules), Romberg's method, Gauss-Legendre quadrature method (2- point, 3-point).

Numerical Solution of Ordinary Differential Equations (ODEs): Initial Value Problems (IVPs): Euler's method, Taylor series method, Range-Kutta methods of order 2 & 4. Boundary Value Problems (BVPs): Shooting method, Finite difference method. **Numerical Solution of Partial Differential Equations (PDEs):** Classification of PDEs, Solution using Finite difference methods.

References

1.	Chapra, S.C. and Canale, R.P., 2011. Numerical Methods for Engineers. McGraw-Hill Education.
2.	Atkinson, K.E. and Han, W., 2006. Elementary Numerical Analysis. John Wiley & Sons, Inc.
3.	Gerald, C.F. and Wheatley, P.O., 2009. Applied Numerical Analysis. Pearson Education India.
4.	Conte, S.D. and De Boor, C., 2017. Elementary Numerical Analysis: An Algorithmic Approach. Society for Industrial and Applied Mathematics.
5.	Mathews, J.H. and Fink, K.D., 2015. Numerical methods using MATLAB. Pearson Education India.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To solve linear system of equations and EVPs numerically.
CO2	To find the roots of nonlinear equations using appropriate numerical scheme.
CO3	To interpolate a function.
CO4	To find numerical differentiation and integration of a function.
CO5	To solve ODEs and PDEs numerically.

Course Code	:	MEOE21
Course Title	:	**Elementary Continuum Mechanics**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce indicial notation and summation convention for vectorial and tensorial operations
CLO2	To introduce basic tensorial calculus for understanding continuum behavior of matters in cartesian coordinates.
CLO3	To familiarize the kinematics of continuum body deformation
CLO4	To familiarize the configuration dependent stress measures
CLO5	To understand the fundamental balance principles of continuum objects

Course Content

Tensor - Introduction: Scalar, Vector, Second order Tensors, Indicial notation and summation convention, Dot, cross and dyadic products, Linear Transformation, Spherical & deviatoric projectors, Coordinate Transformation.

Tensor - Calculus: Eigen values and eigen vectors, Transformation of Tensors, Tensor valued functions, gradient operators and Integral theorems.

Kinematics: Reference and deformed configurations, motion – velocity and acceleration in material & spatial representation, Deformation and displacement gradients, material and spatial stains measures, Line, area, and volume mappings, Nanson's formula, Polar decomposition - Rotation & stretch tensors, rate of deformation.

Kinetics: Concept of stress, Cauchy's stress theorem, first and second Piola-Kirchoff's & Cauchy's stress tensors, Normal and shear stress, Extremal stress values, stress states.

Balance Principles: Mass conservation, Reynold's transport theorem, Momentum and energy balances in references and current configuration, Weak and strong forms of balance equation, Continuum thermodynamics.

References

1.	Gerhard A. Holzapfel, Nonlinear solid mechanics: A Continuum approach for Engineering, Wiley, ISBN: 978-0-471-82319-3 ,2000.
2.	W Michael Lai, David H. Rubin, Erhard Krempl, David Rubin, Introduction to Continuum Mechanics, Butterworth-Heinemann; 4th edition, ISBN: 978-9380501581.
3.	J.N. Reddy, An Introduction to Continuum Mechanics, Cambridge University Press; 2nd edition, ISBN: 978-1316614204.
4.	George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw Hill; First edition, ISBN: 978-9389691283
5.	John W. Rudnick, Fundamentals of Continuum Mechanics, Wiley, ISBN: 978-1-118-92767-0, 2014.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To apply indicial notation and Einstein’s summation convention for tensor operation.
CO2	To represent physical parameters in tensorial notations and perform tensor calculus.
CO3	To understand the unified theory of continuum body such as fluids and solids undergoing deformation.
CO4	To differentiate stress and strain measures on a material and spatial point.
CO5	To represent linear momentum balance in material and spatial configuration

Course Code	**:**	MEOE22
Course Title	**:**	**Modern Automotive Technology**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	Nil
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on the constructions, functions and technological features of electric and hybrid vehicles.
CLO2	To imbibe the utilization of fuel cells and uses of alternative energy systems.
CLO3	To familiarize the various controls and safety features used in modern vehicles.
CLO4	To study the uses of modern peripheral systems and vehicle automated tracks used in automobiles.
CLO5	To understand the various modern features and developments in latest automobiles.

Course Content

Electric and Hybrid Vehicle Technology: Introduction, LEV, TLEV, ULV & ZEV, Basic components of Electric vehicles, Basic factors to be considered for converting automobiles to electric vehicle, electric hybrid vehicle, types - series and parallel hybrid, layouts, comparison, Power systems and control. Electric propulsion with cables – Magnetic track vehicles. Vehicle Operation and Control: Computer Control for fuel economy, pollution and noise.

Fuel Cells and Alternative energy systems: Proton exchange membrane fuel cells, alkaline electrolyte fuel cells, medium and high temperature fuel cells, fuel selection and processing, fuel cell stacks, fuel cell auxiliary systems. Recent Trends in Automotive Power Plants: Stratified charged / lean burn engines – Hydrogen Engines

Principle of Automobile Navigation and controls in the new generation cars. Capabilities of the navigation and control in future cars. Driver Assistance Systems in Automobiles: Vision in cars, A comprehensive driver assistance approach – Lane recognition, Traffic sign recognition, Stereo vision, road recognition, Object recognition – Traffic lights and signals, Building intelligent systems in new generation cars.

Vehicle Automated Tracks: Preparation and maintenance of proper road network-National highway network with automated roads and vehicles-Satellite control of vehicle operation for safe and fast travel. Introduction to electronic traction control and stability control. Brief introduction to driverless cars.

Modem electronic and micro control systems in automobiles: Electronically controlled concealed headlight systems, Electro chromic mirrors, automatic review mirrors, Day time running lamps (DRL), Head up display, Travel information systems, On board navigation system, Electronic climate control, Electronic cruise control, Antilock braking system, Electronically controlled sunroof, Anti-theft systems, Automatic door locks (ADL), engine management system, chassis control system, Integrated system. Modern Developments in Automobiles.

References

1.	Chris Mi, M. Abul Masrur, Electric Vehicles, 2nd Edition, Wiley, 2017.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, CRC Press, 2004.
3.	Tom Denton, Automobile Electrical and Electronics System, Routledge, 2017.
4.	Tom Denton, Electric and Hybrid Vehicles, Routledge, 2020.
5.	Barry Hollembeak, Automotive Electricity, Electronics and Computer Controls, S.Chand (G/L) & Company Ltd , 1998.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To know the suitable control system for different electrical vehicles application.
CO2	To possess the knowledge about various alternative energy systems and fuel cells.
CO3	To identify various modern features for better functioning of vehicle.
CO4	To demonstrate various safety features and equipment used in modern vehicle
CO5	To apply the fundamental knowledge in developing modern vehicle systems.

Course Code	:	MEOE23
Course Title	:	**Hydrogen - Production Handling and Storage**
Type of Course	:	Open Elective (OE)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the various methods of hydrogen production, including conventional and renewable approaches.
CLO2	To explore the technologies and safety measures involved in the handling and storage of hydrogen.
CLO3	To analyze the economic, environmental, and technical challenges associated with hydrogen as an energy carrier.
CLO4	To evaluate the role of hydrogen in the context of sustainable energy systems and its potential in various applications.
CLO5	To develop strategies for the implementation and optimization of hydrogen technologies in various sectors.

Course Content

Historical Perspective and Evolution of Hydrogen Use, Hydrogen's Role in the Energy Transition, Physical and Chemical Properties of Hydrogen, Hydrogen Handling and Safety: Hydrogen Properties and Hazard Identification, Safety Protocols for Handling Hydrogen, Hydrogen Leak Detection and Mitigation. Materials Compatibility and Hydrogen Embrittlement, Codes, Standards, and Regulations for Hydrogen Safety

Hydrogen Production Technologies- Conventional Methods: Steam Methane Reforming, Coal Gasification, Partial Oxidation of Hydrocarbons. Renewable Methods: Water Electrolysis (Alkaline, PEM, Solid Oxide), Biomass Gasification, Photoelectrochemical Water Splitting, Thermochemical Water Splitting, Biological Hydrogen Production. Emerging Technologies: Plasma-Assisted Hydrogen Production, Green Hydrogen via Wind and Solar Integration

Hydrogen Storage Technologies: Physical Storage: Compressed Gas Storage, Liquid Hydrogen Storage, Cryogenic Storage Systems. Material-Based Storage: Metal Hydrides, Chemical Hydrides, Carbon-Based and Novel Materials for Hydrogen Adsorption. Advanced Storage Solutions: Solid-State Storage Technologies, Challenges in Scaling Up Hydrogen Storage Solutions

Hydrogen Transportation and Infrastructure: Hydrogen Pipelines and Distribution Networks, Road and Rail Transport of Hydrogen, Marine Transport of Liquid Hydrogen, Development of Hydrogen Refueling Infrastructure. Case Studies: Global

Hydrogen Infrastructure Projects, Economic and Environmental Aspects of Hydrogen, Cost Analysis of Hydrogen Production Methods, Life Cycle Assessment of Hydrogen Production and Use, Carbon Footprint and Environmental Impact, Hydrogen Economy: Opportunities and Barriers, Policy and Incentives for Hydrogen Deployment

Applications of Hydrogen, Hydrogen in Fuel Cells: PEMFC, SOFC, and MCFC. Hydrogen as a Fuel for Transportation, Industrial Applications of Hydrogen, Hydrogen in Power Generation and Grid Integration, Hydrogen for Energy Storage and Backup Power Systems. Research Directions: Advances in Hydrogen Production and Storage Technologies, Hydrogen Blending in Natural Gas Grids, Potential for Hydrogen in Decarbonizing Hard-to-Abate Sectors, Research and Development Priorities in Hydrogen Technology

References

1.	S.A. Sherif, D. Yogi Goswami, E.K. (Lee) Stefanakos, Aldo Steinfeld, “Handbook of Hydrogen Energy”, 1st Edition, 2014.
2.	zimas, E., Filiou, C., Peteves, S.D., &Veyret, J.B. “Hydrogen storage: state-of-the-art and future perspective. Netherlands”: European Communities, 2003.
3.	Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009.
4.	Michael Hirscher, “Handbook of Hydrogen Storage”, Wiley-VCH, 2010.
5.	Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009
6.	Anand Ramanathan, Babu Dharmalingam, Vinoth Thangarasu, “Advances in Clean Energy Production and Application”, Taylor & Francis, CRC Press, 2020
7.	Anand Ramanathan, Meera Begum, Amaro Pereira, Claude Cohen, “A Thermo-economic Approach to Energy from Waste”, Elsevier, 2021.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand and explain various hydrogen production technologies, including both conventional and renewable methods.
CO2	Demonstrate knowledge of the safety considerations, handling, and storage technologies for hydrogen.
CO3	Perform economic and environmental assessments of hydrogen as an energy carrier, considering its production, storage, and application.
CO4	Critically evaluate the potential and challenges of hydrogen in future sustainable energy systems and its applications in industry, transportation, and power generation.
CO5	Formulate and propose practical solutions for the adoption and enhancement of hydrogen production, handling, and storage systems.

Course Code	**:**	MEOE24
Course Title	**:**	**Engineering Product Realization**
Type of Course	**:**	Open Elective (OE)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the complete product realization lifecycle and systems engineering approach.
CLO2	Translate customer needs into engineering specifications and develop product concepts.
CLO3	Apply product principles, material selection, and manufacturing considerations in product development.
CLO4	Perform prototyping, testing, measurement, and validation of engineering systems.
CLO5	Evaluate economic, reliability, and commercialization aspects of engineering products.

Course Contents

Product Realization Framework & Systems Engineering: Product realization lifecycle - Systems engineering approach, Customer needs vs engineering specifications, Technology Readiness Levels (TRL), Benchmarking and case studies.

Product Architecture & Engineering Design: Functional decomposition, Concept generation techniques, Concept selection (Pugh matrix), Engineering design principles, modeling and validation.

Product Realization: Material selection (Mechanical and economic criteria), Manufacturing processes, Economic Criteria Evaluation, Design for Manufacturability (DFM) and Assembly (DFA), Reliability considerations.

Prototyping, Testing & Validation: Rapid prototyping, Experimental methods, Instrumentation, Method of measurements, Data acquisition, Uncertainty analysis, Performance validation, Design optimization.

Product Deployment & Commercialization: Product lifecycle engineering, Cost estimation, Techno-economic analysis, Intellectual property basics, Standards and certification, Market entry strategies.

References:

1.	Ulrich & Eppinger, Product Design and Development, 7th Edition, MCGraw-Hill Education, 2020.
2.	Donald A. Norman, *The Design of Everyday Things*, Revised Edition, Basic Books, 2013.
3.	Boothroyd, G., Dewhurst, P., & Knight, W. A. Product Design for Manufacture and Assembly, 3rd Edition, CRC Press, 2010.

Pedagogical Approach

Lectures supplemented with case studies, design assignment, and mini-project on product development

Course Outcomes (CO)

At the end of the course student with be able to

CO1	Explain the stages of product realization and apply systems engineering concepts.
CO2	Develop engineering specifications and generate feasible product design concepts.
CO3	Select appropriate materials and manufacturing processes considering design and economic constraints.
CO4	Conduct prototyping, testing, and validation with proper measurement and uncertainty analysis.
CO5	Analyze product lifecycle, cost, reliability, and commercialization strategies.

MINOR (MI) COURSES

Sl. No.	Course Code	Course Title	Credits
1.	**MEMI10**	Basic Thermodynamics	3
2.	**MEMI11**	Fundamentals of Thermal Engineering	3
3.	**MEMI12**	Fluid Mechanics and Machinery	3
4.	**MEMI13**	Fundamentals of Heat and Mass Transfer	3
5.	**MEMI14**	Fundamentals of Automotive Technology	3
6.	**MEMI15**	Fundamentals of Refrigeration and Air Conditioning	3
7.	**MEMI16**	Principles of Turbomachinery	3
8.	**MEMI17**	Fundamentals of Internal Combustion Engines	3
9.	**MEMI18**	Engine Pollution and Control	3
10.	**MEMI19**	Fundamentals of Dynamics	3
11.	**MEMI20**	Fundamentals of Mechanical Design	3

Course Code	:	MEMI10
Course Title	:	**Basics Thermodynamics**
Type of Course	:	Minor (MI)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To achieve fundamental understanding of principles of thermodynamics
CLO2	To be able to use thermodynamic principles for the bulk behavior of the simple physical systems under equilibrium conditions
CLO3	To provide in-depth study of thermodynamic principles and states, basic thermodynamic relations
CLO4	To enlighten the basic concepts of vapor power cycles
CLO5	To understand principles of psychrometry & properties of pure substances

Course Content

Concept of continuum - thermodynamic systems. Property - state - path and process, quasi-static process, work - types of work, Zeroth law of thermodynamics, First law applied to control mass, control volumes. Steady flow energy equation - applications of SFEE

Second law of thermodynamics – statements of second law. Reversibility and irreversibility, Carnot theorem - Carnot cycle, Coefficient of performance. Clausius inequality - concept of entropy - entropy of ideal gas - principle of increase of entropy, Availability.

Properties of pure substances – Thermodynamic properties of pure substances in solid, liquid and vapor phases - phase rule - PVT surfaces, thermodynamic properties of steam. Calculations of work done and heat transfer in non-flow and flow processes.

Gas mixtures – properties ideal and real gases, equation state, Avogadro's Law, Vander Waal’s equation of state, compressibility factor, compressibility chart – Dalton’s law of partial pressure, exact differentials, Maxwell’s relations, Clausius Clapeyron equations, Joule–Thomson coefficient.

Psychrometry, property calculations of air vapor mixtures. Psychrometric process – Sensible heat exchange processes. Latent heat exchange processes.

References

1.	Nag P.K., Engineering Thermodynamics, Tata McGraw-Hill,New Delhi, 1998
2.	Cengel Y.A., Thermodynamics – An Engineering Approach, Tata McGraw Hill, 2003
3.	Borgnakke C Sonntag R.E., Fundamentals of Thermodynamics, John Wiley & Sons, 2009
4.	Jones J.B and Dugan R.E., Engineering Thermodynamics, Prentice-Hall of India, 1998.
5.	Arora C.P., Engineering Thermodynamics, Mcgraw Hill Education, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze any engineering problem based on the basic concepts and logical sequences
CO2	Define the fundamental laws of thermodynamics and explain their application to a wide range of systems.
CO3	Analyze the work and heat interactions associated with a prescribed process path and to perform analysis of a flow system
CO4	Apply the principle of efficient operation on energy utilization and value its impact on the personal and national economy
CO5	Evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations

Course Code	**:**	MEMI11
Course Title	**:**	**Fundamentals of Thermal Engineering**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the working principles of engines, compressors, Steam nozzles and refrigeration systems
CLO2	To solve problem on internal combustion engines and evaluate the performance characteristics
CLO3	To apply the thermodynamics concept to the various thermal energy devices
CLO4	To study the effect of different parameters on the steam nozzles performance
CLO5	To ascertain the performance of refrigeration and air-conditioning systems for a particular application

Course Content

Otto, Diesel, Dual, Brayton cycles, Calculation of mean effective pressure, and air standard efficiency.

Classification - Components and their function - Valve timing diagram and port timing diagram - Comparison of two stroke and four stroke engines - Carburettor system, Diesel pump and injector system.

Flow of steam through nozzles, shapes of nozzles, effect of friction, critical pressure ratio, supersaturated flow, Impulse and Reaction principles, compounding, speed regulations – Governors.

Classification and working principle of various types of compressors, work of compression, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency, multistage air compressor and inter cooling

Vapour compression refrigeration cycle- super heat, sub cooling – Performance calculations - working principle of vapour absorption system, Ammonia – Water, Lithium bromide –water systems, Psychrometry, Psychrometric chart and mollier diagram.

References

1.	Sarkar, B.K,"Thermal Engineering" Tata McGraw-Hill Publishers, 2007
2.	Kothandaraman.C.P., Domkundwar.S,Domkundwar. A.V., "A course in thermal engineering,"Dhanpat Rai &sons ,Fifth edition, 2002
3.	Rajput. R. K., "Thermal Engineering" S.Chand Publishers , 2000
4.	Arora.C.P,"Refrigeration and Air Conditioning ," Tata McGraw-Hill Publishers 1994
5.	Ganesan V." Internal Combustion Engines", Third Edition, Tata Mcgraw-Hill 2007
6.	Rudramoorthy, R, "Thermal Engineering ", Tata McGraw-Hill, New Delhi,2003

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the working principles of engines, compressors, Steam nozzles and refrigeration systems
CO2	Solve problems on internal combustion engines and prepare the heat balance sheet.
CO3	Apply the thermodynamics concept to the various thermal energy devices
CO4	Describe the effect of different parameters on the steam nozzles performance
CO5	Evaluate the performance of refrigeration and air-conditioning systems for a particular application.

Course Code	**:**	MEMI12
Course Title	**:**	**Fluid Mechanics and Machinery**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The student is introduced to the mechanics of fluids through a thorough understanding of the properties of fluids.
CLO2	The dynamics of fluids is introduced through the control volume approach which gives an integrated understanding of the transport of mass, momentum and energy.
CLO3	Students will learn to analyze fluid flow using dimensional analysis.
CLO4	The student is introduced with various classifications of hydraulic machines and their working principles.
CLO5	The student is introduced to analyzing the performances and efficiencies of the hydraulic machines.

Course Content

Units & Dimensions. Properties of fluids – Fluid properties. Fluid statics: Pressure in a fluid - force on submerged planes - buoyancy - equilibrium of floating bodies.

Types of Fluid Flow - one dimensional continuity, momentum and Energy Equations- Flow measurement - Orificemeter - Venturimeter, Pitot tube, orifices, mouthpieces, notches and weirs.

Laminar and turbulent flows - Flow through pipes - Dimensional and Model analysis. Boundary layer concepts.

Pump - Centrifugal pump - types - specific speed - efficiencies. Reciprocating pumps, Indicator diagrams, Work saved by air vessels. Rotary pumps. Classification. Working and performance curves.

Turbines - Hydraulic turbines - types - specific speed - Pelton - Francis and Kaplan turbines - Calculation of power output efficiencies.

References

1.	Streeter. V. L., and Wylie, E.B., Fluid Mechanics, McGraw Hill, 1983.
2.	Rathakrishnan. E, Fluid Mechanics, Prentice Hall of India (II Ed.), 2007.
3.	Ramamritham. S, Fluid Mechanics, Hydraulics and Fluid Machines, Dhanpat Rai & Sons, Delhi, 1988.
4.	Kumar. K.L., Engineering Fluid Mechanics (VII Ed.) Eurasia Publishing House (P) Ltd., New Delhi, 1995.
5.	Som S.K., Biswas G., Chakraborty S., Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill, 3rd ed, 2017
6.	Cengel Y. A., Cimbala J.M., Fluid Mechanics: Fundamentals and Applications, Tata McGraw Hill, 4th ed, 2017

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the properties of fluids and basic principles of fluid mechanics
CO2	Ability to analyze the fluid flow problems with the application of the mass, momentum and energy equations.
CO3	Apply dimensional analysis and modelling techniques to fluid flow problems.
CO4	Determine flow through hydraulics machines and pipes
CO5	Evaluate the performance and efficiency of fluid machines in engineering applications.

Course Code	**:**	MEMI13
Course Title	**:**	**Fundamentals of Heat and Mass Transfer**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn various modes of heat transfer and its applications
CLO2	To understand the applications of various experimental heat transfer correlations in engineering applications.
CLO3	To discuss the thermal analysis and sizing of heat exchangers
CLO4	To understand the basic concepts of mass transfer.
CLO5	To study the phase change heat transfer phenomenon

Course Content

Conduction - general 3-D equation – one dimensional steady state heat conduction in simple geometries – plane wall – cylinder and sphere – composite walls – critical thickness of insulation –types and applications – fin efficiency and effectiveness - unsteady state heat conduction.

Convection - boundary layer theory – conservation equation of mass – momentum and energy for laminar flow over a flat plate – turbulent flow over a flat plate – flow over cylinders – spheres –natural convection – vertical - inclined and horizontal surfaces.

Radiation heat transfer – thermal radiation – laws of radiation - Black and Gray bodies – shape factor-radiation exchange between surfaces - Radiation shields - Greenhouse effect.

Boiling and condensation – pool boiling regimes and correlations – critical heat flux flow boiling – correlations- Nusselt's theory.

Heat exchangers - Fouling factor, LMTD and NTU methods - Mass transfer - Fick's law - analogy between heat and **mass transfer.**

References

1.	Incropera, F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 5th ed., John Wiley, 2002.
2.	Holman, J.P., Heat Transfer, 9th ed., Tata McGraw-Hill, 2004.
3.	Ozisik, M.N., Heat Transfer - A Basic Approach, McGraw-Hill, 1985.
4.	Cengel, Y.A., Heat Transfer - A Practical Approach, McGraw-Hill, 1998.
5.	R.C. Sachedva(2001) fundamentals of heat and mass transfer, New age international.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Explain about the real time applications of heat transfer in both solids and fluids.
CO2	Describe the fundamentals of natural and forced convective heat transfer process.
CO3	Design the heat exchange equipment.
CO4	Explore the real time applications of radiation mode of heat transfer.
CO5	Relate the mass transfer concepts for various industrial applications.

Course Code	**:**	MEMI14
Course Title	**:**	**Fundamentals of Automotive Technology**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the construction and working principle of various parts of an automobile.
CLO2	To have the practice for assembling and dismantling of engine parts and transmission system
CLO3	To understand the manual and automatic transmission systems.
CLO4	To understand vehicle running and control systems.
CLO5	To evaluate engine modifications, performance, emissions for alternative fuels and understand the basics of EV and hybrid technologies.

Course Content

Types of automobiles, vehicle construction and different layouts, chassis, frame and body.

Electronically controlled gasoline injection system for SI engines, electronically controlled diesel injection system, Electronic ignition system, Turbo chargers, Catalytic converter.

Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, over drive, transfer box, fluid flywheel –torque converter, propeller shaft, slip joints, universal joints.

Steering geometry and types, types of Front Axle, Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System and Traction Control.

Use of Natural Gas, Liquefied Petroleum Gas, Biodiesel and Hydrogen in Automobiles- Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with these alternative fuels. EV and Hybrid vehicles.

References

1.	Kirpal Singh, "Automobile Engineering Vol 1 & 2 ", Standard Publishers, Seventh Edition,1997, New Delhi
2.	Jain,K.K.,and Asthana .R.B, "Automobile Engineering" Tata McGraw Hill Publishers, New Delhi, 2002
3.	Newton, Steeds and Garet," Motor Vehicles ", Butterworth Publishers,1989
4.	Joseph Heitner, "Automotive Mechanics,", Second Edition, East-West Press ,1999
5.	Martin W. Stockel and Martin T Stockle, "Automotive Mechanics Fundamentals," The Good heart –Will Cox Company Inc, USA, 1978
6.	Heinz Heisler, 'Advanced Engine Technology," SAE International Publications USA,1998
7.	Ganesan V." Internal Combustion Engines", Third Edition, Tata McGraw-Hill ,2007

Course Outcomes (CO)

At the end of the course student will be able

CO1	To develop electronically modified injection systems
CO2	Identify the use of fuels and its emission characteristics
CO3	To perform both hydraulic and pneumatic braking systems
CO4	To identify the type of transmission of motion in vehicles
CO5	To evaluate the effects of alternative fuels on engine performance, emissions and the role of EV and hybrid technologies

Course Code	:	MEMI15
Course Title	:	**Fundamentals of Refrigeration and Air Conditioning**
Type of Course	:	Minor (MI)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Grasp the principles of refrigeration and identify the various types of refrigeration systems
CLO2	Describe different refrigeration systems and understand their respective advantages and disadvantages.
CLO3	Gain knowledge of the construction and operation of refrigeration equipment
CLO4	Appreciate the fundamentals of air conditioning and recognize its different types.
CLO5	Learn about the various types of refrigerants and explore the applications of refrigeration across different fields.

Course Content

Introduction about Refrigeration – Definitions of various terms.

Methods of refrigeration. Air refrigeration system. Bell – Coleman cycle. Introduction to Aircraft Air-Conditioning.

Analysis of Vapour compression cycle, Modifications to basic cycle and its types, System construction and Operation.

Psychrometry – Definitions for properties. Introduction to cooling load calculations.

Air-conditioning systems – discussion about the central plant with direct evaporator and chiller applications, Ice storage plants, Applications.

References

1.	Arora, R.C., Refrigeration and Air Conditioning, PHI Pvt Ltd, 2010
2.	Dossat R.D., Principle of Refrigeration, 4th ed., Prentice-Hall, 1997.
3.	Manohar Prasad, Refrigeration and Air Conditioning, New Age International, 2004.
4.	Domkundwar Arora C P, Refrigeration and Air Conditioning, Tata McGraw-Hill New Delhi, 3rd Edition, 2010
5.	Stoecker N.F and Jones, Refrigeration and Air Conditioning, TMH NewDelhi,2nd edition 1982.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the principle of refrigeration and know the types of refrigeration
CO2	Explain the concept of various refrigeration systems and familiar with their advantages and disadvantages
CO3	Demonstrate the constructional and working of refrigeration equipment's
CO4	Appreciate the concept of Air Conditioning and know their types
CO5	Identify the different types of refrigerants and Application of refrigeration to various areas

Course Code	**:**	MEMI16
Course Title	**:**	**Principles of Turbomachinery**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the operating principles of various turbomachines and analyze their use for various engineering applications.
CLO2	To construct and interpret velocity triangles for performance evaluation.
CLO3	Students will learn to Apply dimensionless parameters for analyzing turbomachines.
CLO4	To analyze the design and operation of fans and blowers.
CLO5	To analyze the design and operation of compressors and turbines.

Course Content

Classification of Turbomachines. Energy transfer between fluid and rotor - Euler equation and its interpretation.

Velocity triangles. Thermal, Mechanical and overall efficiencies. Polytropic efficiency. Degree of reaction.

Dimensionless parameters for Turbomachines.

Centrifugal Fans and Blowers

Centrifugal and Axial Flow Compressors

Axial and Radial Flow Turbines

References

1.	Yahya, S.H., Turbines, Compressor and Fans, 3rd Edition, Tata McGraw Hill, 2005.
2.	Ganesan, V., Gas Turbines, Tata McGraw Hill Pub. Co.2010.
3.	Saravanamutto HIH, Cohen H., Rogers CEC. & Straznicky PV, Gas Turbine Theory, 6th Edition, Printice Hall, 2009.
4.	Turbo Machines, B.U.Pai , 1st Editions, Wiley India Pvt, Ltd.
5.	Principals of Turbo machines, D. G. Shepherd, The Macmillan Company (1964)

Course Outcomes (CO)

At the end of the course student will be able

CO1	To explain the various systems, principles and applications and different types of turbomachinery components
CO2	To evaluate the efficiencies of various turbomachines.
CO3	To use dimensional analysis to design physical or numerical experiments and to apply dynamic similarity.
CO4	To analyze and evaluate the performance of centrifugal fans and blowers.
CO5	To analyze and evaluate the performance of compressors and turbines.

Course Code	**:**	MEMI17
Course Title	**:**	**Fundamentals of Internal Combustion Engines**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the underlying principles of operation in different IC Engines
CLO2	To provide knowledge on pollutant formation and control.
CLO3	To study the different alternative fuels adopted for IC engines
CLO4	To understand the working of various engine subsystems
CLO5	To evaluate the engine combustion and performance characteristics

Course Content

Spark ignition Engine mixture requirements – Fuel and injection systems – Mono point, Multipoint injection, direct injection – Stages of combustion. Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems– Combustion chambers

Pollutant – Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, NOx, Smoke and Particulate matter – Methods of controlling Emissions

Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel

Air assisted Combustion, Homogeneous charge compression ignition engines – Variable Geometry turbochargers – common Rail direct Injection Systems – Hybrid Electric vehicles – fuel Cells.

References

1.	K.K. Ramalingam, Internal Combustion Engine Fundamentals, SciTech Publications, 2002.
2.	R.B. Mathur and R.P. Sharma, Internal Combustion Engines.
3.	V. Ganesan, Internal Combustion Engines, II Edition, TMH, 2002.
4.	Duffy Smith, Auto Fuel Systems, The Good Heart Willox Company, Inc., 1987
5.	John B Heywood, Internal combustion engines: fundamentals, , McGraw-Hill, 1988

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Explain the working principle of Internal Combustion Engines
CO2	Understand the mechanism of different subsystem employed with IC engines
CO3	Describe the use of different alternative fuels for IC engines
CO4	Evaluate the engine combustion and performance parameters
CO5	Explain the emission formation mechanism and the methods adopted to control it

Course Code	**:**	MEMI18
Course Title	**:**	**Engine Pollution and Control**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To create an awareness on the various environmental pollution aspects and issues.
CLO2	To give a comprehensive insight into the pollution in engine and gas turbines.
CLO3	To provide information of the various subsystems involved in an engine test cell
CLO4	To impart knowledge on pollutant formation and control.
CLO5	To impart knowledge on various emission instruments and techniques.

Course Content

Atmospheric pollution from Automotive and Stationary engines and gas turbines, Global warming– Greenhouse effect and effects of I.C. Engine pollution on environment.

Formation of oxides of nitrogen, carbon monoxide, hydrocarbon, aldehydes and Smoke, Particulate emission. Effects of Engine Design - operating variables on Emission formation – Noise pollution.

Non-dispersive infrared gas analyzer, gas chromatography, chemiluminescent analyzer and flame ionization detector, smoke meters – Noise measurement and control.

Engine Design modifications, fuel modification, evaporative emission control, EGR, air injection, thermal reactors, Water Injection, catalytic converters, application of microprocessor in emission control. Common rail injection system, Particulate traps, NOx converters, SCR systems. GDI and HCCI concepts

Transient dynamometer, Test cells, Driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards.

References

1.	Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980
2.	Ernest, S., Starkman, Combustion Generated Air Pollutions, Plenum Press, 1980.
3.	George Springer and Donald J.Patterson, Engine emissions, Pollutant Formation and Measurement, Plenum press, 1972.
4.	Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers, 1980.
5.	Degobert, Paul. "Automobiles and Pollution, Society of Automotive Engineers." Inc., Warrendale, PA 146 (1995).

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Learn about pollution formation in engines
CO2	Comprehend the methodology used in emission control devices
CO3	Understand the methods adopted to protect the environment from various types of pollution
CO4	Explain the working principle of various instruments used for emission measurement
CO5	Describe the procedure adopted for emission measurement in engine test cell

Course Code	:	MEMI19
Course Title	:	**Fundamentals of Dynamics**
Type of Course	:	Minor (MI)
Prerequisites	:	NIL
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the dynamics principles of a body.
CLO2	To develop mathematical models of point and rigid bodies in rectilinear and curvilinear motions.
CLO3	To analyze the kinematics of point and rigid body systems.
CLO4	To determine the motion of point and rigid body systems in space and time.
CLO5	To impart knowledge on basics of vibration.

Course Content

Rectilinear Translation: Kinematics of rectilinear motion-Principles of dynamics-Differential equation of rectilinear motion-Motion of a particle acted upon by a constant force-Force as a function of time-Force proportional to displacement: free vibrations-D' Alembert's Principle-Momentum and impulse-Work and energy-Ideal systems: conservation of energy-Impact.

Curvilinear Translation: Kinematics of curvilinear motion-Differential equations of curvilinear motion-Motion of a projectile- D'Alembert's principle in curvilinear motion-Moment of momentum-Work and energy in curvilinear motion.

Rotation of a Rigid Body about a Fixed Axis: Kinematics of rotation-Equation of motion for a rigid body rotating about a fixed axis-Rotation under the action of a constant moment-Torsional vibration-The compound pendulum-General case of moment proportional to angle of rotation-D'Alembert's principle in rotation-Resultant inertia force in rotation-The principle of angular momentum in rotation -Energy equation for rotating bodies-Gyroscopes.

Plane Motion of a Rigid Body: Kinematics of plane motion-Instantaneous center-Equations of plane motion-D' Alembert's principle in plane motion-The principle of angular momentum in plane motion-Energy equation for plane motion.

Introduction of Vibration: Fundamentals: Types of vibrations, spring and damping elements, Single degree of freedom systems – free undamped: translations, torsional vibrations, Rayleigh's Energy method. Free damped vibrations: viscous damping-coulomb damping.

References

1.	Ferdinand P Beer, E Russel Johnston, D F Mazurek, P J Cornwell, B P Self, S Sanghi, Vector Mechanics for Engineers – Statics and Dynamics, McGraw Hill Education(India) Private Limited – 12th Edition, ISBN- 978-9353166625, 2019.
2.	Timoshenko S, and Young D.H, J. V. Rao, S. Patil, Engineering Mechanics, McGraw Hill, ISBN- 978-1259062667, 2015.
3.	Irving H Shames, G. K. Mohana Rao, Engineering Mechanics – Statics and Dynamics, Pearson Education India – 4th Edition, ISBN- 978-8177581232, 2005.
4.	William T Thomson., Theory of Vibration with Applications, CBS Publishers, New Delhi, 1990.
5.	Singiresu S. Rao., Mechanical Vibrations, Pearson Education, ISBN-10: 1-292-17860-4, 2018.

Course Outcomes

At the end of the course student will be able to

CO1	Apply basic principles that govern the dynamics of particles and rigid bodies.
CO2	Solve the kinematics of point and rigid bodies in rectilinear and curvilinear motions.
CO3	Demonstrate the rotation of rigid body about a fixed axis.
CO4	Examine the kinematics of planar motion of a rigid body.
CO5	Understand the basics concepts of vibration and its terminology.

Course Code	**:**	MEMI20
Course Title	**:**	**Fundamentals of Mechanical Design**
Type of Course	**:**	Minor (MI)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Intended to provide an introduction to the design process.
CLO2	Impart the Fundamental information on materials in selecting the most appropriate materials, processes and methods to transform his ideas into a successful product.
CLO3	To understand the effect of various loads and corresponding deformation and stresses in mechanical components
CLO4	To learn the procedure to design various mechanical components such as shafts, springs, bearing etc.,
CLO5	To understand the factors involved in the design of flexible elements and gears.

Course Content

Introduction to Mechanical Engineering Design, Materials – Significance of Materials properties, Strength and Stiffness, Hardness, Impact strength, Thermal effects, Ferrous and Non-ferrous metals, Plastics and Composites, Material Selection.

Load and Stress Analysis – Equilibrium and Free-body diagrams, Shear force and Bending moments in beams, Stress and Strains, Deflection and Stiffness – Spring rates, Tension, Compression and Torsion, Deflection due to bending, Strain Energy.

Failures resulting from Static Loading – Static Strength, Stress Concentration, Failure theories.

Design of Mechanical Elements – Shaft and Shaft Components, Screws, Fasteners, Springs – Helical and leaf springs, Rolling contact bearings, Gears – Spur and Helical gears.

References

1.	Joseph Edward Shigley, Mechanical Engineering Design, McGraw-Hill, Tenth Edition in SI units, 2017.
2.	Robert L. Norton, Machine Design – An Integrated approach, Pearson Education, 2011
3.	U.C. Jindal, Machine Design, Pearson Education India, 2010
4.	Design Data: Data Book of Engineers by PSG College-Kalaikathir Achchaga, Coimbatore, 2012.
5.	Sundararajamoorthy, T.V. and Shanmugam, N., Machine Design, Anuradha Agencies, ISBN: 81-87721-20-0, 2003

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the design process, material selection, calculation of stresses and stress concentrations under static loading.
CO2	Differentiate various modes of failures in mechanical components.
CO3	Design the basic mechanical components like shafts, fasteners, Springs and Bearings
CO4	Summarize the knowledge in Gears, Types of gears and its applications.
CO5	Select an appropriate machine element for suitable applications.

Essential Programme Laboratory Requirement (ELR)

Sl. No.	Course Code	Course Title	Credits
1.	**MELR11**	Manufacturing Technology Laboratory	2
2.	**MELR12**	Computer Aided Design Lab	2
3.	**MELR13**	Thermal Engineering Laboratory	2
4.	**MELR14**	Strength of Materials and Fluid Mechanics Laboratory	2
5.	**MELR15**	Heat Transfer and RAC Laboratory	2
6.	**MELR16**	Metrology and Measurements Laboratory	2
7.	**MELR17**	Dynamics Laboratory	2
8.	**MELR18**	Automobile Engineering Laboratory	2

Course Code	**:**	MELR11
Course Title	**:**	**Manufacturing Technology Laboratory**
Type of Course	**:**	Laboratory (ELR)
Prerequisites	**:**	NIL
Contact Hours	**:**	2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To demonstrate proficiency in performing various lathe operations, including simple turning, step turning, taper turning, thread cutting, drilling, and boring.
CLO2	To apply advanced machining techniques such as shaping (V-cutting), milling (indexing operations), and grinding (surface and cylindrical grinding) to produce precise components.
CLO3	To understand and execute gear manufacturing processes using hobbing techniques for spur gear production.
CLO4	To perform experiments on CNC machines, including operations such as simple turning, step turning, and thread turning.
CLO5	To apply additive manufacturing technologies, including selective laser sintering and fused deposition modeling, for creating 3D printed parts and prototypes.

Course Content

1. Lathe – Simple / Step / Taper Turning, Thread Cutting, Drilling and Boring.
2. Shaping – V – Cutting
3. Milling – Job requiring Indexing.
4. Hobbing – Spur Gear Cutting
5. Grinding – Surface / Cylindrical grinding
6. CNC Lathe – Simple Turing, Step Turning, Thread Turing
7. Machining Center – A typical job production.
8. Selective laser sintering and Fused Deposition Modelling – Modelling of a 3D part using SolidWorks/CATIA and tessellation of surfaces using MAGICS/MIMICS software for processing in RP machine.
9. Additive manufacturing/3D printing

References

1.	Hajra Choudhury, A. K., Hajra Choudhury, N. K., & Nirjhar Roy, P. (2020). Elements of workshop technology, volume II. Media Promoters & Publishers.
2.	Kalpakjian, S., & Schmid, S. R. (2024). *Manufacturing Engineering and Technology* (11th ed.). Pearson.
3.	Groover, M. P. (2022). *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems* (8th ed.). Wiley.
4.	Jain, R. K. (2020). Production Technology. Khanna Publishers.
5.	Gibson, I., Rosen, D. W., & Stucker, B. (2015). *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing* (2nd ed.). Springer.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To demonstrate proficiency in fabricating components using a range of lathe operations.
CO2	To produce precise components by applying advanced machining techniques such as shaping, milling, and grinding.
CO3	To execute gear manufacturing processes using hobbing to create spur gears effectively.
CO4	To perform and analyze CNC machining operations, demonstrating practical skills and understanding.
CO5	To utilize various additive manufacturing technologies to design and produce 3D printed parts and prototypes.

Course Code	:	MELR12
Course Title	:	**Computer Aided Design Lab**
Type of Course	:	Laboratory (ELR)
Prerequisites	:	NIL
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Parametric modelling & detailed engineering drawings
CLO2	Assembly & interference analysis
CLO3	Design optimization & productivity
CLO4	Reverse Engineering, Integration of AI tools in design
CLO5	Fundamentals of Digital Twins for mechanical systems

Tools Suggested

Primary CAD: PTC Creo / SolidWorks / Siemens NX / Autodesk Inventor
AI Integration: ChatGPT, CoPilot for CAD, Autodesk Generative Design
Digital Twin: ANSYS Twin Builder / Siemens NX Digital Twin / MATLAB / Simulink

Course Content

Introduction & CAD Environment - CAD System Overview: Features, File types, Standards, User interface, menus, toolbars, views, settings, Coordinate systems and units.

2D Sketching & Drafting - Basic Entities: lines, arcs, circles, splines, Constraints & Dimensions, Layers, Notes, Symbols, Orthographic & Isometric sketching, Engineering drawings per ISO/ASME standards.

3D Part Modelling - Parametric design: Features & relations, Extrude, Revolve, Sweep, Loft, Fillets, Chamfers, Shells, Drafts, Patterns & Mirrors.

Assembly Modelling - Assembly creation & constraints, Interference & clearance analysis, Exploded views & BOM extraction, Assembly motion (basic).

Engineering Drawings from 3D Models - Deriving 2D drawings from 3D parts & assemblies, Sectional, auxiliary views, Tolerances, surface finishes & annotations

Reverse Engineering & Geometry Reconstruction- 3D Scanning-Based Reverse Engineering, Fundamentals, Measurement techniques, Mesh generation and repair, Surface reconstruction, Parametric redesign

AI-Assisted CAD & Generative Design - Integrating AI assistants with CAD, Prompt engineering for design automation, Automated feature creation

Generative Design - Topology optimization, Constraint-based generative output, Multi-objective design exploration

Digital Twin Fundamentals - Digital Twin, Sensor data integration, Parametric model ↔ real system linkage, Simulation-based predictions

References

1.	Jami J. Shah, Martti Mäntylä, Parametric and Feature-Based CAD/CAM: Concepts, Techniques, and Applications, John Wiley & Sons, 3 Nov 1995.
2.	David C. Planchard, Engineering Design with SOLIDWORKS 2024, CSWP, SDC publications, 2024.
3.	Sandeep Dogra, AutoCAD 2024: A Power Guide for Beginners and Intermediate Users, CADArtifex, 2023.
4.	Alejandro Reyes, Beginner's Guide to SOLIDWORKS 2024, SDC Publications, 2024.
5.	Autodesk Learning Hub, SolidWorks Students Guide, Creo / Siemens NX official tutorials.

Course Outcomes (CO)

At the end of the course, students will be able

CO1	Create accurate 2D engineering sketches and detailed drawings using industry-standard CAD tools in accordance with ISO/ASME standards and GD&T practices.
CO2	Develop parametric 3D solid and surface models of mechanical components using feature-based modelling techniques and design intent principles.
CO3	Construct and analyse multi-component assemblies, perform interference detection, motion validation, and generate bill of materials (BOM) for manufacturing applications.
CO4	Apply AI-assisted design and generative modelling techniques to optimize mechanical components under defined constraints and performance criteria.
CO5	Explain and implement the fundamental concepts of Digital Twin technology by integrating CAD models with simulation and real-time data for performance prediction and validation.

Course Code	:	MELR13
Course Title	:	**Thermal Engineering Laboratory**
Type of Course	:	Laboratory (ELR)
Prerequisites	:	NIL
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide knowledge on testing of fuels properties and lubricating oils
CLO2	To demonstrate and conduct experiments, interpret and analyze data and report the results of various thermal systems
CLO3	To understand the valve and port timing diagram of internal combustion engines
CLO4	To analyse the performance characteristics of air compressor
CLO5	To ascertain the engine performance and emission characteristics

Course Content

1. Valve timing and port timing diagrams.
2. Heat balance test on 4-stroke water cooled and Air-cooled Engine.
3. Morse test on multi-cylinder four stroke SI Engine.
4. Performance test on multi-cylinder four stroke Engine.
5. Performance test on single cylinder two stroke Engine
6. Performance and combustion studies on computerized IC engine test rig.
7. Study and performance test on a reciprocating Air Compressor
8. Determination of viscosity using Redwood viscometer.
9. Flash point and Fire point test using Cleveland apparatus.
10. Flash point and Fire point test using Pensky Martens apparatus.
11. Determination of calorific value for liquid and gaseous fuels.
12. Measurement of exhaust gas emissions.
13. Determination of derived cetane number of fuels using cetane analyzer
14. Determination of moisture content in fuel using Karl Fischer Coulometry
15. Study the elemental composition of fuel using ultimate analyzer
16. Categorize the organic compounds of fuel using proximate analysis.

References

1.	Moran, M.J., Moran, H. N. Shapiro, D.D. Boettner, and M.B. Bailey, "Fundamentals of engineering thermodynamics". John Wiley & Sons, 2010.
2.	John Heywood, Internal Combustion Engine Fundamentals, 2nd edition, McGraw Hill, 2018.
3.	P.K. Nag, Basic and Applied Thermodynamics – 2nd Edition, 3rd edition, Tata McGraw-Hill, 2017.
4.	T. D. Eastop and A. McConkey, Applied Thermodynamics for Engineering Technologists, 5th Edition, Pearson, 2003.
5.	Anand Ramanathan, Babu Dharmalingam, Vinoth Thangarasu, "Advances in Clean Energy Production and Application", Taylor & Francis, CRC Press,2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Determine the property of fuels and lubricating oils.
CO2	Evaluate the performance characteristics of internal combustion engines
CO3	Explain the valve and port timing diagram of internal combustion engines
CO4	Interpret the emission characteristics of internal combustion engines.
CO5	Evaluate the performance of air compressors

Course Code	**:**	MELR14
Course Title	**:**	**Strength of Materials and Fluid Mechanics Laboratory**
Type of Course	**:**	Laboratory (ELR)
Prerequisites	**:**	NIL
Contact Hours	**:**	2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the mechanical properties of materials when subjected to different types of loading.
CLO2	To study the behavior of springs under various loading condition.
CLO3	To verify the principles of Fluid Mechanics by performing experiments in the laboratory.
CLO4	To correlate various flow measuring devices such as Venturi meter, Orifice meter, Rotameter, and notches etc.
CLO5	To familiarize with different fluid machinery and their applications.

Course Content

Strength of Materials - List of Experiments

1. Tension test on mild steel rod.
2. Torsion test on mild steel rod.
3. Impact test on mild steel specimens (Charpy and Izod tests).
4. Hardness test on metal specimens (Rockwell and Brinell Hardness Tests).
5. Compression and stretch tests on helical springs (open coil and closed coil).
6. Deflection of Simply supported beams.

Fluid Mechanics - List of Experiments

1. Characteristics of Centrifugal, Reciprocating, Submersible, and Gear pumps.
2. Characteristics of Francis and Kaplan turbines.
3. Coefficient of discharge of V-notch.
4. Flow through Venturi meter, Orifice meter, and Rotameter.
5. Major and minor losses in pipe flow.
6. Determination of Metacentric height of a floating object.

References

1.	Strength of Materials Laboratory Manual, Department of Mechanical Engineering, NIT Tiruchirappalli.
2.	Fluid Mechanics & Machines Laboratory Manual, Department of Mechanical Engineering, NIT Tiruchirappalli.
3.	Crandall, S.H., Dahl, N.C., Lardner, T.J. and Sivakumar, M.S., 2017. An Introduction to Mechanics of Solids. McGraw Hill Education; 3rd edition.
4.	Mubeen, A., 1993. Experimental Strength of Materials, Khanna Publishers.
5.	Majumdar, B., 2011. Fluid Mechanics with Laboratory Manual. PHI Learning Private Limited.

Course Outcomes (CO)

At the end of the course, student will be able

CO1	To perform Tension, Torsion, Bending, Impact, and Hardness tests on solid materials.
CO2	To evaluate the behavior of helical springs when subjected to compression or stretching.
CO3	To assess the capacity of a material to withstand stresses for safe and sustainable design of machine elements.
CO4	To perform various tests on different fluid machinery.
CO5	To use different equipment for flow measurement.

Course Code	:	MELR15
Course Title	:	**Heat Transfer and RAC Laboratory**
Type of Course	:	Laboratory (ELR)
Prerequisites	:	NIL
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To Perform and analyze heat transfer experiments focusing on conduction, convection, and radiation
CLO2	To operate, and assess the performance of various heat exchangers, understanding their role in thermal management systems.
CLO3	Analyze and evaluate the performance of vapor compression and vapor absorption refrigeration systems through experimental studies.
CLO4	To conduct and interpret performance tests on air conditioning systems, understanding the principles of their operation and efficiency.
CLO5	Gaining insights into the mechanisms and applications of thermal energy transfer.

Course Content

1. Heat transfer experiments based on conduction and convection.
2. Heat transfer experiments based on radiation.
3. Experiments on heat exchangers.
4. Study and performance tests on vapor compression refrigeration.
5. Study and performance tests on vapor absorption refrigeration.
6. Study and performance tests on air conditioning test rig.

References

1.	Cengel Y.A., Afshin J.G., Heat and Mass Transfer: Fundamentals & Applications, 6th ed., McGraw-Hill, 2020.
2.	Bergman T.L., Lavine A.S., Incropera F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley & Sons, 2012.
3.	Arora, C.P., Refrigeration and Air Conditioning, 2nded., Tata McGraw-Hill, 2000.
4.	Dossat R.D., Principle of Refrigeration, 4th ed., Prentice-Hall, 1997.
5.	Holman J.P., Heat Transfer, 10th ed., Tata McGraw-Hill, 2010.

Course Outcomes (CO)

At the end of the course, student will be able

CO1	To demonstrate conduction, convection and radiation heat transfer through experiments.
CO2	To interpret heat transfer enhancement mechanisms.
CO3	To estimate the size of heat exchangers.
CO4	To calculate the cooling load of air conditioning systems and cooling towers.
CO5	To develop a deep understanding of the mechanisms and practical applications of thermal energy transfer

Course Code	:	MELR16
Course Title	:	**Metrology and Measurements Laboratory**
Type of Course	:	Laboratory (ELR)
Prerequisites	:	NIL
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Identify the uncertainties in dimensional metrology and the define the measurement standards.
CLO2	Describe the fundamentals of dimensional and geometrical tolerances;
CLO3	Measure length and angles using line-graduated instruments, i. e. Vernier calipers, micrometers, bevel protractor, sine bar and surface plates;
CLO4	To understand and use various measuring instruments - dial indicator, Coordinate Measuring Machine, Profile projector and Video measurement system
CLO5	To familiarize with the use of statistical quality charts.

Course Content

1. Measurements using precision instruments - Vernier caliper, micrometer, Vernier height gauge, depth micrometer, bore gauge, telescopic gauge.
2. Measurement of linear dimensions using Comparators.
3. Measurement of angles using bevel protractor and sine bar.
4. Measurement of screw thread parameters – Screw thread Micrometers and Three wire method (floating carriage micrometer).
5. Measurement of gear parameters – disc micrometers, gear tooth vernier caliper.
6. Measurement of features using Coordinate Measuring Machine (CMM).
7. Measurement using Toolmaker's microscope / Profile projector and Video measurement system.
8. Measurement of Surface finish using stylus-based instruments.
9. Calibration of LVDT.
10. Statistical Quality Control charts.

References

1.	L. Krishnamurthy and N. V. Raghavendra. “Engineering Metrology and Measurements” Oxford University Press, 2013.
2.	L. A. Mironoviskii and Valery A. Slaev, “Metrology and Theory of Measurement” De Gruyter Studies in Mathematical Physics Book 20, 2013.
3.	AIAG, “Measurement Systems Analysis”, Seychelles, 2010.
4.	D.A. Levitch, “Introduction to Measurement Science" Wiley Publications, 2019.
5.	R. Venkat Reddy, Engineering Metrology and Measurements, Invincible Publication, New York, 2021.

Course Outcomes (CO)

At the end of the course, student will be able

CO1	To illustrate on different metrological tools and perform measurements in quality impulsion.
CO2	To describe and explain the working of precision instruments.
CO3	To outline of electronic comparator, optical flat, surface roughness, gear thickness measuring instruments.
CO4	To demonstrate the statistical quality control chart.
CO5	To distinguish with the different instruments that are available for linear, angular, roundness and roughness measurements.

Course Code	**:**	MELR17
Course Title	**:**	**Dynamics Laboratory**
Type of Course	**:**	Laboratory (ELR)
Prerequisites	**:**	NIL
Contact Hours	**:**	2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To equip students with understanding of the fundamental principles of dynamics.
CLO2	To develop a model of mechanical system using a free body diagram.
CLO3	To develop equations of motion for translational and rotational mechanical systems.
CLO4	To perform and understand balancing of rotating body
CLO5	To appreciate the importance of gyroscope in practical applications

Course Content

1. Measurement of moment of inertia of rigid bodies.
2. Gyroscope.
3. Linear vibration.
4. Torsional vibration.
5. Static and dynamic balancing of rotating masses.
6. Geared system

References

1.	Robert L. Norton., “Design of Machinery: an introduction to synthesis and analysis of mechanisms and machines”, McGraw-Hill Education, ISBN - 978-9351340201, 2017.
2.	George H. Martin., “Kinematics and Dynamics of Machines” 2nd ed., Waveland PrInc., 2002.
3.	David H Myszka, Machines & Mechanisms: Applied Kinematic Analysis, Pearson – 4th Edition, ISBN-978-0132157803, 2010.
4.	Amitabha Ghosh, Asok Kumar Mallik, Theory of Mechanisms and Machines, East-West Press – 3rd Edition, ISBN – 978-8185938936, 1988.
5.	S.S. Rattan, Theory of Machines, McGraw Hill -5th Edition, ISBN – 978-9353166281, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Compute the moment of inertia of rigid bodies
CO2	Demonstrate the working principles of gyroscope.
CO3	Experiment with balancing of rotating mass
CO4	Measure the mechanical vibrations in machines
CO5	Know the limitations and advantages of geared system

Course Code	:	MELR18
Course Title	:	**Automobile Engineering Laboratory**
Type of Course	:	Laboratory (ELR)
Prerequisites	:	NIL
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop skills on troubleshooting and maintenance of automobiles.
CLO2	To impart knowledge on EV charging and BTMS
CLO3	To understand various sensors and ECU of an automobile.
CLO4	To impart knowledge on alternate fuels and its performance in IC engine.
CLO5	To understand aerodynamics and NVH of an automobile.

Course Content

1. Studies on garage tools, equipment and automobile maintenance schedule.
2. Dismantling, troubleshooting & assembly of automobile components.
3. Studies on EV charging and Battery Thermal Management of Batteries (BTMS).
4. Studies on automotive sensors and Electronic Control Unit (ECU)
5. Tests on alternate fuels and engine performance using chassis dynamometer.
6. Measurement and verification of exhaust gas with emission standards.
7. Experiments on wheel balancing and wheel rotation.
8. Inspection of tyre wear pattern and verification of wheel alignment.
9. Studies on aerodynamics of an automobile.
10. Studies on Noise, Vibration and Harshness (NVH).

References

1.	Newton, K., Steeds, W., and Garrett, T.K., The Motor Vehicle, Butterworth, 1989.
2.	Joseph Heitner, “Automotive Mechanics”, 2nd edition, East-West Press, 1999.
3.	Kirpal Singh, Automotive Engineering, Vol. I & II, Standard Publishers, New Delhi, 1997
4.	Tom Denton, Automobile Electrical & Electronic Systems (5th Edition), Taylor and Francis, 2018.
5.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design, 3rd Edition, CRC Press, 2018.

Course Outcomes (CO)

At the end of the course, student will be able

CO1	To troubleshoot and maintain automobiles as per SoP.
CO2	To demonstrate EV charging and battery thermal management systems.
CO3	To distinguish various sensors and ECU of an automobile.
CO4	To experiment alternate fuels on the performance of an IC engine.
CO5	To experiment alternate fuels on the performance of an IC engine.

HONOURS (HO) Courses

Sl. No.	Course Code	Course Title	Credits
1.	**MEHO10**	Advanced Heat Transfer	4
2.	**MEHO11**	Advanced Fluid Mechanics	4
3.	**MEHO12**	Advanced Engineering Materials	4
4.	**MEHO13**	Design of Heat Exchangers	4
5.	**MEHO14**	Design and Optimization of Thermal Energy Systems	4
6.	**MEHO15**	Fuels Combustion and Emission Control	4
7.	**MEHO16**	Advanced Computational Methods in Engineering	4
8.	**MEHO17**	Computational Continuum Mechanics	4
9.	**MEHO18**	Heat Transfer Equipment Design	4
10.	**MEHO19**	Analysis and Design of Pressure Vessels	4
11.	**MEHO20**	Design and Analysis of Turbo Machines	3
12.	**MEHO21**	Analysis of Thermal Power Cycles	3
13.	**MEHO22**	Boiler Auxiliaries and Performance Evaluation	3
14.	**MEHO23**	Environmental Pollution Control	3

Course Code	:	MEHO10
Course Title	:	**Advanced Heat Transfer**
Type of Course	:	Honours (HO)
Prerequisites	:	Heat and Mass Transfer (MEPC19)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course learning Objective

CLO1	To understand steady state and transient heat conduction
CLO2	To compare, design and optimization of different fin profiles for engineering applications
CLO3	To understand boundary layers and to formulate convection correlations
CLO4	To understand the phase change heat transfer in engineering applications
CLO5	To discuss thermal radiation, view factor, gas radiation, radiation effect on temperature measurement.

Course Content

Steady state heat conduction, Extended surfaces – Steady state analysis - Longitudinal fin of rectangular, triangular and spline profile radiating to free space – Radial fins, Transient heat conduction.

Boundary Layer Theory – Momentum and energy equations (With Proof) Simplification of the Momentum Equations, Simplification of the Energy Equations – Internal and external flows – Forced convection – turbulence in convection, correlations for convection.

Heat transfer with phase change – Condensation and boiling heat transfer phenomena, Laminar Film Condensation on a Vertical Plate (With Proof), Condensation on Outer Surface of a Horizontal Tube, Effect of non-condensable gases in condensing equipment – Relations for boiling heat transfer, heat pipe.

Thermal radiation – View factor - Radiation shields, Radiation energy Exchange– Gas radiation –Effect of Radiation on temperature in engineering applications.

References

1.	Ozisik, M.N., *Heat Transfer - A Basic Approach*, McGraw-Hill, 1987.
2.	Bejan, A., *Heat Transfer*, John Wiley & Sons Inc., 1993.
3.	Kakac, S. and Yener, Y., *Convective Heat Transfer*, CRC Press, 1995.
4.	Kraus, A.D., Aziz, A., and Welty, J., *Extended Surface Heat Transfer*, John Wiley, 2001.
5.	Bergman T.L., Lavine A.S., Incropera F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley & Sons, 2012.
6.	Eckehard Specht, Heat and Mass Transfer in Thermoprocessing: Fundamentals, Calculations, Processes, Vulkan Verlag, 2017. ISBN: 9783802729911.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Discuss and analyze about steady state and transient heat conduction.
CO2	Analyze and optimize various fins like rectangular, triangular and parabolic profiles for heat transfer applications.
CO3	Understand and solve thermal boundary layers, momentum and energy equations
CO4	Comprehend the heat transfer associated with phase changes in engineering applications.
CO5	Analyze thermal and gas radiation in heat transfer equipment.

Course Code	:	MEHO11
Course Title	:	**Advanced Fluid Mechanics**
Type of Course	:	Honours (HO)
Prerequisites	:	Fluid Mechanics and Machinery (MEPC15)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize with the properties of fluids and the applications of fluid mechanics.
CLO2	To classify flows and to understand and apply the conservation principles for fluid flows.
CLO3	To formulate and analyse fluid problems related to calculation of drag and lift forces.
CLO4	To understand the principles of dimensional analysis.
CLO5	To develop a basic understanding of the characteristics of turbulent flows with their engineering applications.

Course Content

Introduction to indicial notation of representing vectors and tensors – inner and outer products – directional derivatives – gradient, divergence and curl – Divergence & Stokes theorems.

Fluid Kinematics - Reynold’s transport theorem - Physical conservation laws - Integral and differential formulations - Navier-Stokes and energy equations - Dimensionless forms and dimensionless numbers.

Two-dimensional Potential flows - Different types of flow patterns, elementary complex potentials and their superpositions – uniform flow past cylinder – method of images – circle theorem - conformal mapping.

Exact Solution of Navier-Stokes equations – Couette flow - Poiseuille Flow – flow between rotating cylinders – Stokes first and second problems.

Momentum integral approach - Boundary layer concept - Boundary layer thickness- Prandtl’s equations - Blasius solution-skin friction coefficient.

Turbulent flows - Reynolds equation and closure problems, free and wall bounded shear flows- Prandtl and von Karman hypothesis- Universal velocity profile near a wall-flow through pipes.

References

1.	Kundu, P.K., Ira Cohen, M., Dowling, DR., Fluid mechanics, Elsevier, 1990.
2.	Currie, LG., Fundamental Mechanics of Fluids, 3rd ed., CRC Press, 2002
3.	White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
4.	Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press, 1995
5.	Tennekesse, H. and Lumley, JL., A first course in turbulence, MIT Press, 1971
6.	Jog, C.S., Fluid Mechanics - Foundation and Application of Mechanics (volume 2), Cambridge Uni. Press, 3rd ed., 2015

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the principles of continuity, momentum, and energy as applied to fluid flow
CO2	Recognize these principles written in form of mathematical equations.
CO3	Express any fluid-flow problem as a set of governing equations and identify appropriate boundary conditions
CO4	Solve simple fluid flow problems using appropriate mathematical techniques
CO5	Apply dimensional analysis to predict physical parameters that influence the flow in fluid

Course Code	:	MEHO12
Course Title	:	**Advanced Engineering Materials**
Type of Course	:	Honours (HO)
Prerequisites	:	Engineering Materials (MEPC18)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Distinguish various classes of advanced materials, their processing, properties and applications
CLO2	Interpret ultra-light materials, Biomaterials, coatings and thin films, composites, and high temperature refractory materials for aerospace applications.
CLO3	Distinguish materials suitable for application at elevated temperatures and identify coatings suitable for protection applications
CLO4	Introduction and application of Smart materials and meta-materials.
CLO5	Understand the computational methods in material science

Course Content

Ultralight materials and metallic foams, material definition and processing, characterization of cellular metals, material properties

Composite materials, classifications, properties, dispersion strengthening, metal matrix composites, and applications.

Advanced materials - coatings and high- temperature materials, , Bio-Materials, Thin Films, Liquid crystals.

Smart Materials: Stimuli responsive materials, Light actuators, Heat actuators, etc. Shape memory Alloys – characterization and application, Piezoelectric, Magnetostrictive materials.

Meta-Materials: Introduction to structural, vibrational and acoustic Meta-materials. Functionally graded materials.

Computational material modelling, Introduction to various scales and multi-scale modelling: Atomistic (Molecular dynamics), Meso-Scale, Macroscale (continuum) modelling methods of materials.

References

1.	Handbook of Cellular metals, Production, processing, Application, Edited by Hans Peter Degischer and Brigitte Kriszt, Wiley - VCH, 2002.
2.	Biomaterials Science, An Introduction to Materials in Medicine, Edited by B.D. Ratner, A.S. Hoffman, F.J. Sckoen, and J.E.L Emons, Academic Press, second edition, 2004.
3.	Handbook of Materials for Medical Devices, Edited by J. R. Davis, ASM international, 2003.
4.	W. E. Smith, Structure & Properties of Engineering Alloys, McGraw Hill, 1993
5.	F.L. Matthews & R. D. Rawlings, Composite Materials Engg. & Science, 1994
6.	D.R. Askeland, P.P. Fulay, W.J. Wright. The Science and Engineering of Materials. 6th ed. Cengage Learning, Inc (2010)

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand types, manufacturing processes, and applications of advanced materials viz. ultra-light materials, composites, etc.
CO2	Will have knowledge of various types of smart materials responding to various external stimuli
CO3	Will recognize the importance and need for design, manufacture and utilize the newer materials to overcome contemporary issues.
CO4	Will have the knowledge of meta-materials pertaining to structural, vibrational and acoustics.
CO5	Will appreciate the need of various computational methods (at various scale) pertaining to material modelling.

Course Code	:	MEHO13
Course Title	:	**Design of Heat Exchangers**
Type of Course	:	Honours (HO)
Prerequisites	:	Heat and Mass Transfer (MEPC19)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the thermal and stress analysis on various parts of the heat exchangers
CLO2	To analyze the sizing and rating of the heat exchangers for various applications
CLO3	To Understand the merits and demerits of different types of heat exchangers
CLO4	To Understand the performance characteristics of phase change heat exchangers
CLO5	To analyse the working principles of low temperature heat exchangers

Course Content

Types of heat exchangers, shell and tube heat exchangers – regenerators and recuperators Temperature distribution and its implications - Parts description, Classification as per Tubular Exchanger Manufacturers Association (TEMA).

Heat transfer correlations, Overall heat transfer coefficient, analysis of heat exchangers – LMTD and effectiveness method. Sizing of finned tube heat exchangers, Design of shell and tube heat exchangers, fouling factors, pressure drop calculations.

Types- Merits and Demerits- Design of compact heat exchangers, plate heat exchangers, performance influencing parameters, limitations.

Design of surface and evaporative condensers –cooling tower – performance characteristics.

Cryogenic heat exchangers – matrix heat exchangers, coiled tube heat exchangers.

References

1.	Sadik Kakac and Hongtan Liu, "Heat Exchangers Selection," Rating and Thermal Design, CRC Press, 2002.
2.	Shah,R. K., Dušan P. Sekulić, "Fundamentals of heat exchanger design", John Wiley & Sons, 2003.
3.	Robert W. Serth, "Process heat transfer principles and applications", Academic press, Elsevier, 2007.
4.	Sarit Kumar Das, "Process heat transfer", Alpha Science International, 2005
5.	John E. Hesselgreaves, "Compact heat exchangers: selection, design, and operation," Elsevier Science Ltd, 2001.
6.	Kuppan. T., "Heat exchanger design handbook", New York: Marcel Dekker, 2000.
7.	Kays, W.M., and London, A.L., "Compact heat exchangers", Krieger Pub Co., Subsequent edition, 1998.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To apply the mathematical knowledge for thermal and stress analysis on various parts of the heat exchangers components
CO2	To evaluate the sizing and performance ratings of heat exchangers for different applications
CO3	To comprehend the advantages and disadvantages of various types of heat exchangers
CO4	To grasp the performance characteristics of heat exchangers involving phase change
CO5	To examine the operating principles of low-temperature heat exchangers

Course Code	**:**	MEHO14
Course Title	**:**	**Design and Optimization of Thermal Energy Systems**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	Heat and Mass Transfer (MEPC19)
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	describe energy system design and recall regression analysis and equation fitting
CLO2	design thermal equipment like heat exchangers, evaporators, condensers, turbomachines, distillation equipment, absorber, generator, GAX.
CLO3	apply the successive method and Newton Raphson method in energy systems
CLO4	construct mathematical representation for optimization problems in energy systems
CLO5	analyze the cost involved in energy system by present worth-annual cost method

Course Content

Introduction to Energy System Design - Regression analysis and Equation fitting.

Modeling of thermal equipment - heat exchangers, evaporators, condensers, turbomachines, distillation equipment. Absorber, generator, GAX.

System simulation - Application of successive method and Newton Raphson Method to Energy Systems.

Mathematical Representation for Optimization Problems in Energy Systems, Genetic Algorithms – using MATLAB, Inverse problems in heat transfer -Applications of various search methods to Energy Systems - Waste Heat Recovery System - design of energy recovery systems.

Cost analysis by present worth-annual cost-Evaluating potential Investments-Forecasting Techniques-Economic Factors in Energy Systems-Examples.

References

1.	Hodge, B.K. and R.P. Taylor, Analysis and Design of Energy Systems, 3rd Edition, Prentice Hall, 1999.
2.	Stoecker, W.F., Design of Thermal Systems, McGraw-Hill, 1989.
3.	Burmeister, L.C., Elements of Thermal-Fluid System Design, Prentice Hall, 1998.
4.	Jaluria, Y., Design and Optimisation of Thermal Systems, McGraw-Hill, 1998.
5.	Janna, W.S., Design of Fluid Thermal Systems, PWS-Kent Publishing, 1993.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe energy system design and recall regression analysis and equation fitting
CO2	Design thermal equipment like heat exchangers, evaporators, condensers, turbomachines, distillation equipment, absorber, generator, GAX.
CO3	Apply the successive method and Newton Raphson method in energy systems
CO4	Construct mathematical representation for optimization problems in energy systems
CO5	Analyze the cost involved in energy system by present worth-annual cost method

Course Code	**:**	MEHO15
Course Title	**:**	**Fuels Combustion and Emission Control**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study fuels and their properties combustion chemistry and stoichiometry.
CLO2	To solve simplified conservation equations for reacting flows and to compare different types of FBCs.
CLO3	To distinguish the factors influencing flame velocity and thickness flame stabilization.
CLO4	To understand the emission norms and standards.
CLO5	

Course Content

Types of fuels and their properties – fuel production and processing methods – Coal characterization – Propellants – Thermochemistry – Property Relations – Stoichiometry – Heat of reaction/formation – Adiabatic Flame Temperature – Equilibrium Products of Combustion – Mass transfer.

Chemical kinetics – Reaction rates – Chemical Mechanisms – Steady state and Partial equilibrium approximations – Chain reactions and explosion limits – Coupling chemical & thermal analyses of reacting systems.

Simplified Conservation equations for reacting flows – Schvab Zeldovich Formulations – Laminar Premixed Flames – Simplified analysis – Factors influencing flame velocity and thickness – Flammability limits – Quenching – Ignition – Flame stabilization.

Laminar diffusion flames – Droplet evaporation and burning – Turbulent Premixed & diffusion flames – Deflagration and detonation – Rankine-Hugoniot Relations – Detonation structure – Combustion of solid propellants – Combustion instabilities.

Emission formation and reduction mechanism – nitrogen oxides – Sulphur oxides – soot – sooting tendencies – structure – influence of physical and chemical parameters – Emission legislation and control strategies.

References

1.	Irvin Glassman, Nick G. Glumac and Richard A. Yetter, Combustion, 5th edition Academic Press, 2014.
2.	Turns S.R., An Introduction to Combustion: Concepts and Applications, 4th Edition, McGraw Hill, 2021.
3.	Kenneth K Kuo, Principles of Combustion, 2nd edition, John Wiley, 2012
4.	Williams F. A., Combustion Theory, 2nd edition, CRC Press. 2018
5.	Sharma, S.P. and Mohan, C., Fuels and Combustion, Tata McGraw-Hill, 1987.
6.	Sarkar. S., Fuels and Combustion, 3rd edition Universities Press, 2009.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the fuel production or processing methods and their properties
CO2	Determine the flame temperature, stoichiometric ratios and chemical reaction rate
CO3	Apply simplified conservation equations for laminar and turbulent reacting flows.
CO4	Illustrate the factors influencing flame characteristics and emission formation.
CO5	Apply the different principles of flame stabilization and ignition to design combustor.

Course Code	**:**	MEHO16
Course Title	**:**	**Advanced Computational Methods in Engineering**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	NIL
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce various algorithms to find numerical solutions of linear system of equations, nonlinear equations, and EVPs.
CLO2	To learn different methods for interpolating a function numerically.
CLO3	Finding numerical differentiation and integration of a function.
CLO4	To study appropriate numerical methods for solving ODEs and PDEs.
CLO5	To develop computer programs for solving mathematical equations numerically.

Course Content

Introduction: Numerical precision in digital computing and its effect on numerical calculations, Taylor series and truncation, Rounding off errors, Introduction to programming.

Numerical Solution of Linear System of Equations: Direct methods (Cramer's rule, Gauss Elimination method, pivoting, LU factorization method, Cholesky method), Iterative methods (Jacobi method, Gauss-Seidel method). Conditioning, Matrix and vector norms. Numerical Solution of Eigen Value Problems (EVPs): Determinant based method, Transformation based method, Vector iteration method.

Numerical Solution of Nonlinear Equations: Bracketing methods (Bisection, False-position method), Open methods (Newton-Raphson method, Secant method, Fixed-point iteration method). Interpolation and Curve Fitting: Lagrange methods, Newton Methods, Piecewise interpolation methods. Least square linear approximation.

Numerical Differentiation: Forward, Backward and Central difference formulas. Extrapolation technique. Numerical Integration: Newton-Cotes rules (Trapezoidal rule, Simpson's rules), Romberg's method, Gauss-Legendre quadrature method (2- point, 3-point).

Numerical Solution of Ordinary Differential Equations (ODEs): Initial Value Problems (IVPs): Euler's method, Taylor series method, Range-Kutta methods of order 2 & 4. Boundary Value Problems (BVPs): Shooting method, Finite difference method. Numerical Solution of Partial Differential Equations (PDEs): Classification of PDEs, Solution using Finite difference methods.

Laboratory: Coding the above algorithms in MATLAB/C++/Fortran/Python

References

1.	Chapra, S.C. and Canale, R.P., 2011. Numerical Methods for Engineers. McGraw-Hill Education.
2.	Atkinson, K.E. and Han, W., 2006. Elementary Numerical Analysis. John Wiley & Sons, Inc.
3.	Gerald, C.F. and Wheatley, P.O., 2009. Applied Numerical Analysis. Pearson Education India.
4.	Conte, S.D. and De Boor, C., 2017. Elementary Numerical Analysis: An Algorithmic Approach. Society for Industrial and Applied Mathematics.
5.	Mathews, J.H. and Fink, K.D., 2015. Numerical methods using MATLAB. Pearson Education India.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To solve linear system of equations, nonlinear equations, and EVPs numerically.
CO2	To interpolate a function.
CO3	To find numerical differentiation and integration of a function.
CO4	To solve ODEs and PDEs numerically.
CO5	To develop their own programs/subroutines for the numerical schemes taught in the course.

Course Code	:	MEHO17
Course Title	:	**Computational Continuum Mechanics**
Type of Course	:	Honours (HO)
Prerequisites	:	Mechanics of Solids (MEPC14)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To review stress and strain measures in reference and current configurations.
CLO2	To understand the balance principles of continuum objects.
CLO3	To establish the finite element discretization of continuum solids
CLO4	To familiarize the classical metal plasticity and its computational implementations
CLO5	To gain the knowledge of rate dependent material behaviors

Course Content

Fundamentals: Tensor calculus, Eigen values, Transformations, Kinematics of deformation – Velocity and Acceleration, Deformation gradient, Lagrangian and Eulerian strain measures, Polar decomposition, Line, Area, and Volume elements in current configuration, Cauchy's stress theorem, Piola- Kirchoff's & Cauchy's stress tensors, Principal stresses.

Balance Equations: Mass conservation, Reynold's transport theorem, Momentum and energy balances in references and current configuration, Weak and strong forms of balance equation, Continuum thermodynamics, Clausius-Duhem inequality, Constitutive Relations: Fluid and solid constitutive equations, generalized Hooke's law for elastic solids, Navier-Stokes equation for fluids.

Finite Element Method: Virtual work principle, weak form of momentum and energy, Galerkin method, shape functions and Gauss quadrature, 1-D and multidimensional heat transfer problems, Infinitesimal deformation, Linear elastic material – plane strain and plane stress, axisymmetric formulation, tangent modulus, iteration methods, line search algorithm.

Plasticity: Yield criteria, flow rule, isotropic and kinematic hardening rules, consistency conditions, Kuhn-Tucker conditions, 1-D simplification, Bauschinger effect, J2 flow theory, perfect plasticity, 3-D tangent elasto-plastic operator, tensorial projectors in matrix and vector form, return mapping algorithm, Nonlinear hardening rule.

Rate Dependent Behavior: viscoelasticity, classical viscoplasticity, Perzyna model, Creep models, geometrical nonlinearity, multiplicative decomposition, large deformation, thermomechanical behavior.

References

1.	Shabana, Ahmed A. Computational continuum mechanics. John Wiley & Sons, 2018.
2.	Simo, Juan C., and Thomas JR Hughes, Computational inelasticity. Vol. 7., Springer Science & Business Media, 2013, ISBN: 978-1475771695.
3.	EA de Souza Neto, D Peric, DRJ Owen, Computational methods for Plasticity, John Wiley & Sons, 2008.
4.	Gerhard A. Holzapfel, Nonlinear solid mechanics: A Continuum approach for Engineering, Wiley, ISBN: 978-0-471-82319-3 ,2000.
5.	W Michael Lai, David H. Rubin, Erhard Krempl, David Rubin, Introduction to Continuum Mechanics, Butterworth-Heinemann; 4th edition, ISBN: 978-9380501581.
6.	C.S. Jog, Continuum Mechanics: Volume 1: Foundations and Applications of Mechanics, Cambridge University Press, 978-1107091351, 2015.
7.	Bertram, Albrecht. Elasticity and plasticity of large deformations. Springer-Verlag Berlin Heidelberg, 2005.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To compute the stress, and strain in different configurations and its transformations.
CO2	To understand the fundamental balance equations of fluids and solids.
CO3	To discretize the weak form of differential equations and solve using FEM.
CO4	To predict the nonlinear material behavior using classical plasticity
CO5	To apply the rate dependent inelastic models in thermomechanical applications.

Course Code	:	MEHO18
Course Title	:	**Heat Transfer Equipment Design**
Type of Course	:	Honours (HO)
Prerequisites	:	Heat and Mass Transfer (MEPC19)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize students with the different types of heat transfer equipment and various flow patterns.
CLO2	To make students learn and analyze shell and tube heat exchangers, and other types of heat exchangers for special services
CLO3	To make students learn the design procedure of air pre-heaters, economizers, super heaters, condensers and cooling towers for thermal power plants
CLO4	To make students design plate and compact heat exchangers for industrial applications
CLO5	To make students analyse and design cooling towers

Course Content

Classification of heat transfer equipment - Design of shell and tube heat exchanger - Finned surface heat exchanger –Heat exchangers for special services – Fired heaters

Plate and spiral plate heat exchanger – plate heat exchanger for Dairy industry – Heat Pipes

Thermal design of heat exchange equipment such as Air pre-heaters , Economizer – Super heater and condensers.

Selection of compact heat exchangers. Analysis and design of cooling towers.

References

1.	Ganapathy, V., Applied Heat Transfer, Pennwell Books, 1982.
2.	Kays, W.M. and London, A.L., Compact Heat Exchangers, McGraw-Hill, 1998.
3.	Dunn, P. and Reay, D.A., Heat Pipes, Pergamon, 1994.
4.	Kakac, S. and Liu, H., Heat Exchangers, CRC Press, 2002.
5.	Arthur P. Frass, Heat Exchanger Design, John Wiley & Sons, 1988
6.	Hewitt G.F., Shires G.L. and Bott T.R., Process Heat Transfer, CRC Press, 1994.
7.	Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981.
8.	Sekulic D.P., Fundamentals of Heat Exchanger Design, John Wiley, 2003.
9.	TaborekT., Hewitt.G.F. and Afgan N., Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Classify and state the various heat transfer equipment
CO2	Design various heat exchangers viz. shell and tube, finned surface & special purposes for thermal engineering industries.
CO3	Analyze and determine the performance parameters of air pre-heaters, economizers, super heaters and condensers for power plants.
CO4	Design compact heat exchangers and cooling towers.
CO5	Select a suitable heat exchanger for any given application

Course Code	:	MEHO19
Course Title	:	**Analysis and Design of Pressure Vessels**
Type of Course	:	Honours (HO)
Prerequisites	:	Mechanics of Solids (MEPC14)
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart basic knowledge of the design of pressure vessels and piping systems.
CLO2	To introduce the various standards used for the pressure vessel design.
CLO3	To understand the development of cracks, fracture mechanisms and corrosion
CLO4	To perform finite element analysis on high-pressure and temperature components
CLO5	To introduce use of various standards used for the pressure vessel design.

Course Content

Establishment of design conditions – Fracture Mechanics – Heads, Basic shell thickness - Reinforcement of openings – Special components like flange, tube plate, supports.

Cylindrical shells – Thick cylinders- Lame's solution - Theories of breakdown of elastic action – Unrestrained solution – Lateral loading – General loading. Axisymmetric loading - Membrane solutions - Edge bending solutions - Flexibility matrix.

Application of general analysis – Flat closure plates –conical heads and reducers – hemispherical and torispherical, ellipsoidal heads.

Development of cracks - Fracture mechanics - Corrosion - Selection of working stress for ductile and brittle materials.

Finite element analysis for high-pressure and high-temperature components

Pressure vessel design case studies and assignments utilizing BIS codes.

References

1.	Bickell, M.B. and Ruiz, c., Pressure Vessel Design and Analysis, MacMillan, London, 1967.
2.	Den Hartog, J.P., Advanced Strength of Materials, McGraw-Hill, 1949.
3.	Timoshenko, S., Strength of Materials, Van Nostrand, 1986.
4.	Dennis Moss, Pressure vessel design manual, Gulf Professional Publishing, 2004.
5.	John F. Harvey, Theory and Design of Pressure Vessels, Van Nostrand Reinhold Company, New Yark, 1985.

Course Outcomes (CO)

At the end of the course, students will be able to

CO1	Analyze thin plates and shells for various types of stresses.
CO2	Design shells, end closures, and nozzles of pressure vessels using ASME codes.
CO3	Understand the fracture and corrosion mechanism
CO4	Analyze the FEM models on high-pressure and temperature components
CO5	Analyze the general applications of pressure vessel

Course Code	:	MEHO20
Course Title	:	**Design and Analysis of Turbomachines**
Type of Course	:	Honours (HO)
Prerequisites	:	Fluid Mechanics and Machinery (MEPC15)
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make students learn the basics of isentropic flow and velocity diagrams in turbomachines
CLO2	To make students analyze and solve problems on centrifugal compressor
CLO3	To make students learn and state the working of a combustion chamber
CLO4	To make students learn about the different types of turbines and the associated performance parameters
CLO5	To make students analyse and select a turbine for a given application

Course Content

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations - area-ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler's equation for turbomachines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic

Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working– velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses

Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - cooling of combustion chamber

Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines.

Gas turbine cycle analysis – simple and actual. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scramjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, and specific fuel consumption, thermal and propulsive efficiencies.

References

1.	Ganesan, V., Gas Turbines, McGraw-Hill Education, ~~2011~~ 2017
2.	Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications,2012
3.	Saravanmotto, H.I.H., Rogers, G.F.C., Cohen, H., Straznicky, P.V., and Nix, A.C., Gas Turbine Theory, Pearson 7^{th} edition, 2017
4.	Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion Pearson 2^{nd} edition, 1991
5.	Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill Education, 1st Edition. 1997

Course Outcomes (CO)

At the end of the course student will be able

CO1	To explain basic concepts of turbomachines and visualize dimensional analysis.
CO2	To describe the working of Pelton, Francis and Kaplan along their performance parameters.
CO3	To discuss the operation of centrifugal pumps, centrifugal and axial compressors.
CO4	To associate the effect of cavitation in turbines and pumps.
CO5	To express the basic cycles and calculations involved in the operation of steam and gas turbines.

Course Code	**:**	MEHO21
Course Title	**:**	**Analysis of Thermal power cycles**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	Thermal Engineering (MEPC16)
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To describe sources of energy and types of power plants**.**
CLO2	To analyze different types of steam cycles and estimate efficiencies in a steam power plant
CLO3	To define the performance characteristics and components of power plants
CLO4	To study and analyze various refrigeration cycles
CLO5	To Evaluate the advantages of thermal power system

Course Content

Steam power plant cycle - Rankine cycle - Reheat cycle - Regenerative cycle with one and more feed heaters - Types of feed heaters - Open and closed types - Steam traps types.

Cogeneration - Condensing turbines - Combined heat and power - Combined cycles - Brayton cycle Rankine cycle combinations - Binary vapour cycle.

Air standard cycles - Cycles with variable specific heat - fuel air cycle - Deviation from actual cycle.

Brayton cycle - Open cycle gas turbine - Closed cycle gas turbine - Regeneration - Inter cooling and reheating between stages.

Refrigeration Cycles - Vapour compression cycles - Cascade system - Vapour absorption cycles - GAX Cycle.

References

1.	Thermodynamics: An Engineering approach by Yunus cengel, McGraw Hill Education, July 2017
2.	Arora, R.C., Refrigeration and Air Conditioning, PHI Pvt Ltd, 2010
3.	Nag. P.K., Engineering Thermodynamics, 3rd ed., Tata McGraw-Hill, 2005.
4.	Nag. P.K., Power Plant Engineering, 2nd Tata McGraw-Hill, 2002
5.	Culp, R., Principles of Energy Conversion, McGraw-Hill, 2000.

Course Outcome

At the end of the course student will be able to

CO1	Understand various energy resources and conversion methods and equipment.
CO2	Derive efficiency calculation for various power cycles.
CO3	Understand different refrigeration cycles and their operation
CO4	Evaluate the principles of cogeneration, including condensing turbines, combined heat and power systems, and combined cycles, with a focus on the Brayton and Rankine cycle combinations and binary vapor cycles
CO5	Analyze air standard cycles, including cycles with variable specific heat and fuel-air cycles, and understand deviations from actual cycles in practical applications.

Course Code	**:**	MEHO22
Course Title	**:**	**Boiler Auxiliaries and Performance Evaluation**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	To understand the concepts of boiler types, circulation system and desuperheaters
CLO2	To understand the types of fuel and ash handling equipment
CLO3	To learn feed pumps and air draft system
CLO4	To familiarize with the working principal of electrostatic precipitator
CLO5	To learn soot blowers' selection, operation and maintenance

Course Content

Boiler types – Specification – Circulating systems - Efficiency calculation - Balance diagram –Drum Internals – Desuperheaters.

Fuel and Ash handling Equipment – Mills - Specification – Selection – Operation – Maintenance.

Feed pumps – Different types, Specifications, Operation and maintenance aspects - Fans, blowers – Applications – Performance requirements, Selection, Operation and maintenance.

Dust cleaning equipment – Selection criteria – Design, operation and maintenance of electrostatic precipitators, Bag filters.

Soot blowers – Various types and their constructional features – Specifications – Selection –Operation and Maintenance.

References

1.	Modern Power Station Practice, CEGB London, Pergamon Press, 1991.
2.	Eck, B., Fans, Pergamon Press, 1973.
3.	Shields, C.D., Boilers, Types Characteristics and Functions, McGraw-Hill, 1961.

Course Outcome

At the end of the course student will be able to

CO1	Understand the concepts of boiler types, circulation systems and desuperheaters
CO2	Understand the types of fuel and ash handling equipment
CO3	Describe the feed pumps and air draft system
CO4	Familiarize with the working principal of electrostatic precipitator
CO5	Explain soot blowers selection, operation and maintenance

Course Code	**:**	MEHO23
Course Title	**:**	**Environmental Pollution Control**
Type of Course	**:**	Honours (HO)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

CLO1	Principles of environmental pollution control
CLO2	Control of various pollutants within the permissible limits
CLO3	Principles and requirements of ISO 14001 standard based environmental management system
CLO4	Effects of air, water pollutants and hazardous wastes on the environment
CLO5	Appropriate tools and techniques to collect and measure environmental pollutants

Course Content

Air Pollution

Biosphere, Biogeochemical Cycles, Classification and properties of air pollutants – Particulate Matter – types, Pollution sources – Effects of air pollutants on human beings, Vegetation and Materials, Scavenging Mechanisms, Electromagnetic Radiation- ultraviolet radiation, infrared radiation, radiation from sun-hazards due to depletion of ozone - deforestation-ozone holes, Chloro Fluoro Carbon (CFC). Air quality monitoring-Ambientand Stack monitoring.

Air pollution sampling and analysis- – dust monitor – gas analyzer, particle size analyzer – pH meter – gas chromatograph – atomic absorption spectrometer. Air pollution controlGravitational settling chambers-cyclone separators-scrubbers-electrostatic precipitator -bag filter – maintenance - control of gaseous emission by adsorption, absorption and combustion methods. Air Pollution Control Board-laws.

Water Pollution

Classification of water pollutants-health hazards; Basics of water quality standards – physical, chemical and biological parameters; BoD and CoD analysis, sampling and analysis of water-water treatment- primary, secondary, tertiary - different industrial effluents and their treatment and disposal –advanced wastewater treatment - effluent quality standards and laws. Water Pollution Control Board-laws.

Hazardous Waste Management

Hazardous waste management in India-waste identification, characterization and classification-technological options for collection, treatment and disposal of hazardous waste-selection charts for the treatment of different hazardous wastes-methods of collection and disposal of solid wastes-health hazards-toxic and radioactive wastes incineration and vitrification - hazards due to bio-process-dilution-standards and restrictions – recycling and reuse.

Pollution Control In Process Industries

Pollution control in process industries like automobile, chemical factory, cement, paper, petroleum and petroleum products, textile-tanneries, thermal power plants, dying and pigment industries, sewage/ effluent treatment plants, nuclear power plants, eco-friendly energy. ISO 14001: 2015 principles and requirements.

Sustainability And ESG

Introduction to Sustainability, Health Safety & Environment, and Environmental Social Governance; ESG Principles; Integrating ESG into HSE Practices; Carbon Neutrality, Zero Discharge, Life Cycle Assessment; Understanding GRI- Global Reporting Initiative and BRSR- Business Responsibility and Sustainability Reporting.

References

1.	Rao, C.S., 2018. Environmental Pollution Control Engineering. New Age International Publishers.
2.	Mahajan, S.P., 2017. Pollution Control in Process Industries. McGraw-Hill Education.
3.	Brauer, H. and Varma, Y.B., 2011. Air pollution control equipment. Springer Science & Business Media.
4.	Municipal Solid Waste Management Manual - Part 1 & 2. Central Public Health and Environmental Engineering Organisation (CPHEEO), India
5.	Essia, U., 2022. Fundamentals of ESG (ESG 101).

Course Outcome

At the end of the course student will be able to

CO1	Classify air and water pollutants and hazardous wastes.
CO2	Apply scientific knowledge to propose control strategies for different pollutants from process industries.
CO3	Use relevant information about environmental impacts of air, water pollutants and hazardous wastes to discuss environmental pollution in a given case.
CO4	Recognize and select appropriate environmental pollutant sampling and measurement techniques.
CO5	Apply relevant statutory and regulatory requirements concerned with environmental pollution.

MICROCREDIT (MC) Courses

Sl. No.	Course Code	Course Title	Credit
1.	**MEMC10**	Peridynamics for Fracture Simulation	1
2.	**MEMC11**	3D Printing and Design Integration	1
3.	**MEMC12**	CAD Fundamentals for Mechanical Design	1
4.	**MEMC13**	AI for Automotive Technology	1
5.	**MEMC14**	Mechanical Testing of Materials	1
6.	**MEMC15**	Granular Mechanics	1
7.	**MEMC16**	Introduction to Vehicle Noise and Vibration Control	1
8.	**MEMC17**	Melting and Solidification of Metals	1
9.	**MEMC18**	Future Fuels	1
10.	**MEMC19**	Introduction to Bioinspired Robotics	1

Course Code	**:**	MEMC10
Course Title	**:**	**Peridynamics for Fracture Simulation**
Type of Course	**:**	Microcredit (MC)
Prerequisites	**:**	NIL
Contact Hours	**:**	12 (4 Weeks) – 1 credit
Course Assessment Methods	**:**	One End Assessment

Course Learning Objectives (CLO)

CLO1	To understand nonlocal formulation of material with discontinuity
CLO2	To understand integral form of linear momentum balance for solids
CLO3	To learn bond based Peridynamics and derive material parameters
CLO4	To understand crack initiation and propagation in brittle materials
CLO5	To appreciate the computational advantages of Peridynamics for cracking problems

Course Content

Review of solid mechanics - deformation gradient, configuration dependent stress-strain measures, Linear and angular momentum balance, strain energy

Peridynamics – Introduction, Continuum and nonlocal theory comparison, force density and micro potential, derivation of linear momentum in integral form

Bond based Peridynamics – 1D and 2D material parameters, volume and surface correction, Simulation of benchmark problems using MATLAB code, comparing with FEM results.

Crack initiation and propagation – Critical stretch derivation from fracture mechanics, implicit method, Explicit method with application to Impact problem.

References

1.	Erdogan Madenci and Erkan Oterkus.,2014. Peridynamic Theory and Its Applications, Springer Science+Business Media New York, ISBN - 978-1-4614-8464-6.
2.	Florin Bobaru, John T. Foster, Philippe H Geubelle, Stewart A. Silling. 2017. Handbook of Peridynamic Modeling, CRC Presss, Taylor and Francis Group, LLC, ISBN – 978-1-4822-3043-7.
3.	Walter Herbert Gerstle., 2016. Introduction to Practical Peridynamics: Computational Solid Mechanics Without Stress and Strain, World Scientific Publishing Co. Pte. Ltd, ISBN 978-9814699549.
4.	Erdogan Madenci, Atila Barut, Mehmet Dorduncu. Peridynamic Differential Operator for Numerical Analysis, Springer Nature Switzerland AG 2019. ISBN 978-3-030-02646-2.
5.	Timon Rabczuk, Huilong Ren, Xiaoying Zhuang. Computational Methods Based on Peridynamics and Nonlocal Operators, Springer Nature Switzerland AG 2023, ISBN ISBN 978-3-031-20905-5.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To differentiate the continuum and peridynamic formulation of solid momentum balance
CO2	To understand bond-based Peridynamics for 1-D and 2-D problems
CO3	To simulate solid deformation problems using Peridynamics
CO4	To understand MATLAB code and simulate impact problems
CO5	To simulate crack initiation and propagation in brittle materials

Course Code	**:**	MEMC11
Course Title	**:**	**3D Printing and Design Integration**
Type of Course	**:**	Microcredit (MC)
Prerequisites	**:**	NIL
Contact Hours	**:**	**12 (4 Weeks) – 1 credit**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand key 3D printing technologies and their applications.
CLO2	Develop proficiency in 3D modeling software
CLO3	Learn to prepare and optimize models for 3D printing
CLO4	Complete a design project that showcases effective integration of design and printing principles.
CLO5	Hands of training on 3D printing.

Course Content

Introduction to 3D Printing and Basic Design: Various printing technologies, Applications in various industries, 3D modelling software, Creating and manipulating simple 3D models.

Advanced Design Techniques: 3D modelling techniques and tools, Design considerations, stl, obj and other file formats, introduction to slicing software.

Hands on printing and Iteration – Printing, Evaluation of print quality and issue identifications. Iterating designs, Optimizing prints and materials. Project and presentation.

References

1.	Christopher Barnatt, 3D Printing The Next Industrial Revolution, Explaining The Future.com, 2013.
2.	Joan Horvath, Rich Cameron, Mastering 3D Printing - A Guide to Modeling, Printing, and Prototyping, Apress, Springer, 2020.
3.	Ben Redwood, Filemon Schöffer, Brian Garret, The 3D Printing Handbook Technologies, Design, And Applications, 3D Hubs B.V., 2017.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To identify and explain various 3D printing technologies.
CO2	To apply design principles to develop accurate and detailed 3D models suitable for printing.
CO3	To prepare and optimize 3D models for printing, including scaling, orientation, and adding supports.
CO4	To use slicing software to generate print-ready files and set appropriate print parameters.
CO5	To print and evaluate 3D models, assessing print quality and making necessary adjustments to improve results.

Course Code	:	MEMC12
Course Title	:	**CAD Fundamentals for Mechanical Design**
Type of Course	:	Microcredit (MC)
Prerequisites	:	NIL
Contact Hours	:	1
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the Basics of CAD Software
CLO2	Develop Skills in 2D Mechanical Drawing
CLO3	Master 3D Modeling Techniques
CLO4	Assemble and Manage Mechanical Components
CLO5	Conduct Basic Design Analysis

Course Content

Introduction to CAD and Basic 2D Design - Introduction to popular CAD software - Basic CAD interface and navigation.

2D Drawing Fundamentals: Creating and modifying 2D sketches - Understanding drawing tools and commands - Dimensioning and annotations.

Basic 3D Modeling: Introduction to 3D Design - Creating 3D Components – Solid Modeling and Surface Modeling.

Assemblies and Advanced Modeling Techniques: Assembling multiple parts into a complete assembly - Understanding constraints and relationships between parts.

Analysis - Introduction to CAD simulation tools (stress analysis, motion simulation).

References

1.	David A. Madsen, David P. Madsen, Engineering Drawing and Design, Cengage Learning, 2016
2.	Prof. Sham Tickoo, Autodesk Fusion 360: A Tutorial Approach, CADCIM Technologies, 2nd Edition, 2020
3.	Godfrey C. Onwubolu, Introduction to SolidWorks: A Comprehensive Guide with Applications in 3D Printing, CRC Press 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Utilize fundamental tools and commands for creating and modifying 2D drawings and 3D models.
CO2	Develop accurate 2D mechanical drawings and Apply drawing standards.
CO3	Create detailed 3D models of mechanical components
CO4	Assemble multiple 3D parts into a cohesive mechanical assembly.
CO5	Conduct basic simulations (such as stress analysis and motion simulation) using CAD tools. Interpret analysis results and make informed design adjustments based on simulation data.

Course Code	**:**	MEMC13
Course Title	**:**	**AI for Automotive Technology**
Type of Course	**:**	Microcredit (MC)
Prerequisites	**:**	NIL
Contact Hours	**:**	**12 (4 Weeks) – 1 credit**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide a foundational understanding of AI and its relevance in the automotive sector.
CLO2	To explore the application of AI in developing autonomous vehicles and enhancing vehicle safety.
CLO3	To introduce AI-driven predictive maintenance and diagnostic systems in automotive technology.
CLO4	To understand the role of AI in optimizing manufacturing processes and the automotive supply chain.
CLO5	To develop hands-on experience with AI tools and techniques relevant to the automotive industry.

Course Content

Introduction to AI in Automotive Technology: Overview of AI and Machine Learning - The significance of AI in modern automotive systems. Case Studies: AI-driven advancements in automotive technology.

AI in Autonomous Vehicles: Key AI technologies in autonomous driving - Perception and environment sensing (Computer Vision, LiDAR, RADAR) - Decision-making algorithms and vehicle control. Ethical and safety considerations in autonomous vehicles.

AI in Predictive Maintenance and Diagnostics: AI-based predictive maintenance models - Diagnostic systems using AI. Case Studies: Real-world applications of AI in vehicle maintenance.

AI in Smart Manufacturing and Supply Chain: AI integration in automotive manufacturing processes AI for supply chain optimization. Case Studies: AI in automotive manufacturing and logistics.

Introduction to AI Tools - TensorFlow, PyTorch, or Scikit-Learn. Autonomous Vehicle Simulation - Simulating AI-driven autonomous driving scenarios. Predictive Maintenance Modeling. Developing and testing AI-based predictive maintenance models. Development and presentation of a small AI-based project relevant to automotive technology.

References

1.	Josep Aulinas, Hanky Sjafrie, AI for Cars, 1st Edition, Chapman and Hall, CRC Press, 2021
2.	Ira Gordon, Artificial Intelligence in Automotive Engineering: The Next Revolution, Kindle Edition, 2024
3.	Mazin Gilbert, Artificial Intelligence for Autonomous Networks, Ist Edition, Chapman & Hall, CRC Press, Taylor & Francis, 2020
4.	Sampo Kuutti, Saber Fallah , Richard Bowden, Deep Learning for Autonomous Vehicle Control: Algorithms, State-of-the-Art, and Future Prospects, Springer, 2019
5.	Inma Martínez, The Future of the Automotive Industry: The Disruptive Forces of AI, Data Analytics, and Digitization, Apress Berkeley, CA, 2021
6.	Felicity Brock, AI in the Automotive Industry: Transforming Cars and Transportation, Independently Published, 2023
7.	Romil Rawat, A. Mary Sowjanya, Syed Imran Patel, Varshali Jaiswal, Imran Khan, Allam Balaram, Autonomous Vehicles Volume 1: Using Machine Intelligence, Scrivener Publishing LLC, 2023

Course Outcomes (CO)

At the end of the course student will be able

CO1	Explain the basic principles of AI and its impact on the automotive industry.
CO2	Demonstrate knowledge of AI technologies used in autonomous vehicles and their challenges.
CO3	Apply AI concepts in predictive maintenance and vehicle diagnostics.
CO4	Analyze the implementation of AI in smart manufacturing and supply chain management.
CO5	Utilize AI tools to develop simple models or simulations for automotive applications.

Course Code	:	MEMC14
Course Title	:	**Mechanical Testing of Materials**
Type of Course	:	Microcredit (MC)
Prerequisites	:	NIL
Contact Hours	:	12 (4 Weeks) – 1 credit
Course Assessment Methods	:	One End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic importance of Engineering materials
CLO2	To imbibe the basic principles of various DT techniques, its applications, limitations, codes and standards.
CLO3	To understand the basic principles, testing procedures and limitations of various NDT methods used for detecting the flaw on the material surface.
CLO4	To realize different NDT techniques used for identifying the surface defects.
CLO5	To equip themselves for locating an internal flaw in various materials, products, etc.

Course Content

Overview of Engineering Materials, Classification and Purpose of Material Testing, Testing organizations and standards, Advantages of Mechanical Testing.

Introduction to Destructive testing (DT), Tensile test, Compression test, Shear test, Impact (Izod and Charpy), fatigue test – Principles, Techniques, Advantages and Disadvantages.

Introduction to Non-Destructive testing (NDT) – Surface Methods: Visual Inspection, Dye/Liquid Penetrant test, Magnetic Particle Test - Principles, Techniques, Advantages and Disadvantages.

Volumetric Methods: Radiographic test, Ultrasonic test (A, B and C scan), Eddy Current test - Principles, Techniques, Advantages and Disadvantages.

References

1.	Harmer E. Davis, George Earl Troxell, George F.W, Hauck, 2015. The Testing of Engineering Materials, Fourth Edition (Indian), McGraw Hill, ISBN 9789339220532
2.	Emmanuel Gdoutos, Maria Konsta-Gdoutos, 2024. Mechanical Testing of Materials Kindle Edition, Springer, ISBN-13-978-3031459894.
3.	Baldev Raj, T.Jayakumar, M.Thavasimuthu, 2011. Practical Non-Destructive Testing, Third Edtion, Narosa Publishing House, ISBN-13- 978-8173197970.
4.	ASM Handbook Volume 8: Mechanical Testing and Evaluation, 2000. ASM International, Metals Park, Ohio, USA, ISBN: 978-0-87170-389-7
5.	ASM Metals Handbook Vol. 17::1989, Non-Destructive Evaluation and Quality Control, ASM International, Metals Park, Ohio, USA, ISBN-13- 978-0871700230

Course Outcomes (CO)

At the end of the course student will be able

CO1	To realize the importance of materials in various engineering fields
CO2	To perform destructive testing of materials
CO3	To have a basic knowledge of surface NDT techniques which enables for carrying out various inspection in accordance with the established procedures.
CO4	To select appropriate NDT methods for internal flaw detection on the materials.
CO5	To acquire the knowledge of interpreting the results of both DT and NDT methods and analyzing the influence of various parameters on the testing.

Course Code	**:**	MEMC15
Course Title	**:**	**Granular Mechanics**
Type of Course	**:**	Microcredit (MC)
Prerequisites	**:**	NIL
Contact Hours	**:**	12 (4 Weeks) – 1 credit
Course Assessment Methods	**:**	One End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the role of granular materials in mechanical industries.
CLO2	To understand the difference between continuous materials and discrete materials
CLO3	To study the mechanical response of granular mechanics- stress-strain response
CLO4	To understand the numerical methods to simulate and study granular mechanics
CLO5	To briefly learn about discrete element modelling of the granular materials.

Course Contents

Introduction to Granular materials: Granular materials, their characteristics and properties, Industrial applications, difference between continuous and discrete materials

Mechanics of granular materials under various loading conditions. Force transmission in granular materials. Closed packing of spherical granular materials.

Introduction to simulation of granular materials. **Discrete element method.** Major steps in the algorithm to simulate the granular materials (Spherical: spheres and discs)

References

1.	Introduction to Discrete Element Modeling: A geomechanics Perspective by O' Sullivan

Course Outcomes (CO)

At the end of the course student will be able

CO1	To appreciate the importance of granular materials in industry.
CO2	To identify the various characteristics of granular materials with respect their response to mechanical loading.
CO3	To know the working algorithm of Discrete element method
CO4	To distinguish between simulation methods of FEM and DEM
CO5	To write a code to simulate simple 2-d granular systems consisting of discs.

Course Code	:	MEMC16
Course Title	:	**Introduction to Vehicle Noise and Vibration Control**
Type of Course	:	Microcredit (MC)
Prerequisites	:	NIL
Contact Hours	:	12 (4 Weeks) – 1 credit
Course Assessment Methods	:	One End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the vibration concepts and classification
CLO2	To propose underlying theory of sound and noises from automobile
CLO3	To describe the methods of vibration control at source
CLO4	To understand the airborne noise and its control measure
CLO5	To reduce the structural borne noise for vehicle subsystems

Course Contents

Introduction to Vibration, Effect of vibrations on a vehicle and human beings, Classification of vibration, Evaluation of natural frequency by Modal analysis.

Theory of Sound, sound wave and propagation, types of sound - airborne, structure borne, interior, exterior noises from automobile.

Methods of vibration control - excitation reduction at source, Dynamic properties and selection of structural materials – Visco-elastic damping, vibration absorbers (Tuned damped, unturned viscous dampers) - Vibration isolation techniques (Active and passive control).

Air borne noise - use of noise absorber, barrier, Dynamic properties, and selection of acoustic materials. Structure borne noise - damping materials for hood liner and head liner, Sound isolation - machine enclosures, silencers, and mufflers.

References

1.	Ra. S.S, Mechanical Vibrations, Pearson Education, 2016.
2.	Colin H. Hansen, Foundations of Vibroacoustics, CRC Press, Taylors and Francis, 2018.
3.	Matthew Harrison, Vehicle refinement (controlling of Noise, Vibration in vehicles), Elsevier Publications, 2004.
4.	David A.Bies and Colin H.Hansen , Engineering Noise Control: Theory and Practice Spon Press, London, 2009.
5.	Xu Wang, Vehicle noise and vibration refinement, Elsevier Publishers, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To classify the vibrations and effect of vibration on human beings.
CO2	To differentiate the types of noises from automobile
CO3	To understand the methods of vibration control at source
CO4	To select the suitable material properties of noise barrier
CO5	To analyze the sound isolation for vehicle subsystems

Course Code	:	MEMC17
Course Title	:	**Melting and Solidification of Metals**
Type of Course	:	Microcredit (MC)
Prerequisites	:	NIL
Contact Hours	:	12 (4 Weeks) – 1 credit
Course Assessment Methods	:	One End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce equilibrium condition for the existence of solid and liquid phases.
CLO2	To familiarize the application of mass, momentum, and energy balance during solidification
CLO3	To introduce the analytical methods for the computation of melting and solidification time.
CLO4	To understand the industrial continuous casting process
CLO5	To explain and practice the finite element techniques for the modeling of solidification process.

Course Content

Thermodynamics: Introduction to Solidification - shape and continuous casting processes, Unary systems -single phase and equilibrium of phases, Binary alloys, Gibb's phase rule.

Balance Equations: Control volume, phase average of gradients and divergences, global and interface mass balance, shrinkage factor, preliminaries of linear momentum balance, energy balance, Stefan condition.

Analytical models: **Melting**: preheating and melting time models, **Solidification:** 1-D analytical quasi-steady models for plate, cylinder, sphere, 1-D semi-infinite model, continuous casting process, 2-D semi-analytical model, mold-solid-liquid domain with melt superheat, Cooling strategies for industrial casting.

Numerical models: Finite element method for heat conducting solids, latent heat effect - enthalpy and temperature recovery-based methods, isothermal and nonisothermal phase change, MATLAB code and COMSOL model development, Simulation of various industrial casting processes.

References

1.	Chalmers, B., Principles of Solidification, R. E. Krieger Publishing Company, 1977
2.	Kurz, W., and Fisher, D.J., Fundamentals of Solidification, Trans Tech Publications Limited, 1998.
3.	Dantzig, J.A., and Rappaz, M., Solidification, EPFL Press, CRC Press, Taylor and Francis Group, 2009.
4.	Martin Eden Glicksman, Principles of Solidification: An Introduction to modern casting and Crystal growth concepts. Springer Science & Business Media, 2011.
5.	Hasse Frediksson, and Ulla Akerlind, Solidification and Crystallization Processing in Metals and Alloys, John Wiley, and Sons, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To gain the knowledge of solid-liquid phase equilibrium
CO2	To arrive the mass, momentum, and energy balances of solidified continuum.
CO3	To compute the melting solidification time of simplified shapes.
CO4	To understand cooling strategies in industrial continuous casting process
CO5	Gain the insight of modelling approaches available in solidification process

Course Code	:	MEMC18
Course Title	:	**Future Fuels**
Type of Course	:	Microcredit (MC)
Prerequisites	:	NIL
Contact Hours	:	12 (4 Weeks) – 1 credit
Course Assessment Methods	:	One End Assessment

Course Learning Objectives (CLO)

CLO1	To Understand the principles and technologies of renewable hydrogen production.
CLO2	To explore various methods of attaining hydrogen economy.
CLO3	To analyze waste-to-fuel conversion processes such as pyrolysis and gasification.
CLO4	To evaluate the environmental and economic impacts of future fuel technologies.
CLO5	To develop strategies for the implementation and integration of future fuels in various sectors.

Course Content

Overview of the global energy landscape and the role of future fuels Introduction to hydrogen as a future fuel: Properties, production methods, and storage challenges. Overview of renewable hydrogen production technologies: Electrolysis (PEM, Alkaline, Solid Oxide), Photolysis, and Thermochemical water splitting

Concept of the hydrogen economy: Production, distribution, and utilization. Hydrogen storage methods: Compressed gas, liquid hydrogen, and metal hydrides

Waste-to-Fuel Conversion Technologies Pyrolysis: converting waste to bio-oil, Gasification: syngas production, and utilization in synthetic fuel synthesis, Plasma-assisted gasification for hydrogen-rich fuel production from waste materials

Environmental benefits of future fuels: Emission reduction, carbon capture, and sustainable development. Economic challenges and opportunities: Cost analysis, scalability, and market adoption. Case studies on the implementation of future fuels in different sectors (transportation, industry, etc.)

References

1.	Gupta, R. B., Hydrogen Fuel: Production, Transport and Storage, CRC Press, Taylor & Francis Group, 2009.
2.	Wachsman, E. D., & Lee, K. T. (2011). *Fuel Cells and Hydrogen Production: Technologies and Market Perspectives*. Wiley-VCH.
3.	Rezaiyan, J., & Cheremisinoff, N. P. (2005). *Gasification Technologies: A Primer for Engineers and Scientists*. CRC Press.
4.	Bridgwater, A. V. (2003). *Pyrolysis Handbook: Biomass and Waste Pyrolysis for Fuel Production*. CPL Press.
5.	Michael Hirscher, "Handbook of Hydrogen Storage", Wiley-VCH, 2010.
6.	Anand Ramanathan, Babu Dharmalingam, Vinoth Thangarasu "Advances in Clean Energy Production and Application", Taylor & Francis, CRC Press, 2020
7.	Anand Ramanathan, Meera Begum, Amaro Pereira, Claude Cohen "A Thermo-economic Approach to Energy from Waste", Elsevier, 2021.
8.	Meera Sheriffa Begum K.M., Anand Ramanathan, Amaro Olimpio Pereira Junior, Dmitrii Glushkov, M. Angkayarkan Vinayakaselvi "Waste to Profit-Environmental Concerns and Sustainable Development", Taylor & Francis, CRC Press, 2023

Course Outcomes (CO)

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

CO1	Demonstrate knowledge of renewable hydrogen production technologies
CO2	Apply various electrolysis methods for hydrogen generation.
CO3	Implement waste-to-fuel conversion processes.
CO4	Assess the environmental and economic impacts of future fuels.
CO5	Formulate and propose practical solutions for the adoption of future fuels in real-world applications.

Course Code	**:**	MEMC19
Course Title	**:**	**Introduction to Bioinspired Robotics**
Type of Course	**:**	Microcredit (MC)
Prerequisites	**:**	NIL
Contact Hours	**:**	3
Course Assessment Methods	**:**	End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize students with different biologically inspired robotic systems
CLO2	To make students learn and analyse the locomotion techniques employed by biological systems to move on terradynamically challenging conditions
CLO3	To make students learn about biological control systems
CLO4	To make students learn about soft robotics and swarm robotics
CLO5	To make students think and explore bioinspired solutions to challenges in robotics

Course Content

Introduction to biologically inspired robotic systems: advantages and disadvantages, mobility in biological systems, bioactuators and biosensors, biological control systems, soft robotics, swarm robotics, exploration of bio-inspired solutions to challenges in robotics

References

1.	Vogel, S., *Comparative Biomechanics: Life's Physical World,* Princeton University Press, 2013
2.	Hill R.W., Wyse G.A., and Anderson M., *Animal Physiology*, Sinauer Associates Inc., 2016
3.	Haberland, M. and Kim, S., *On extracting design principles from biology: I. Method–General answers to high-level design questions for bioinspired robots*. Bioinspiration & Biomimetics, *10*(1), p.016010.
4.	Bar-Cohen, Y., *Biomimetics: Biologically Inspired Technologies*, CRC press, 2005
5.	Fu K.S., Gonzalez R.C. and Lee C.S.G., *Robotics: Control, Sensing, Vision and Intelligence*, McGraw Hill Education (India) Private Limited, 2017

Course Outcomes (CO)

At the end of the course student will be able

CO1	To state or give a presentation on the different bioinspired robotic systems, need and advantages
CO2	To state and implement the locomotion techniques employed by biological systems to engineering systems
CO3	To compare and design robotic actuators and sensors based on biological principles
CO4	To state the basics of soft robotics, ways of fabricating and controlling it
CO5	To explore and implement bio-inspired solutions to challenges in robotics