B. Tech.

IN

MECHANICAL ENGINEERING

FLEXIBLE CURRICULUM

(For students admitted in 2017-18)

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA

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CURRICULUM

The total minimum credits for completing the B.Tech. programme in Mechanical Engineering is 179 [68 + 111].

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech. programmes shall have General Institute Requirements (GIR), Programme Core (PC), Elective Courses (PE, OE and MI) and Essential Programme Laboratory Requirements (ELR) are as follows:

Sl. No.	COURSE CATEGORY	Number of Courses	Number of Credits
1.	General Institute Requirement (GIR)	17	68
2.	Programme Core (PC)	20	62
3.	Essential Programme Laboratory Requirement (ELR)	8	16
4.	Elective courses a. Programme Electives (PE) b. Open Electives (OE) c. Minor (MI) A student should be allowed a minimum of 50% of the total electives of a programme from (b) and (c) if so desired by the student.	11	33
TOTAL			**179**

(I) GENERAL INSTITUTE REQUIREMENTS

Sl.No.	Name of the course	Number of Courses	Maximum Credits
1.	Mathematics	4	14
2.	**Physics***	**2**	**7**
3.	**Chemistry***	**2**	**7**
4.	Humanities	1	3
5.	Communication	2	6
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 Branch of Study)**	**1**	**2**
13.	***Summer Internship***	***1***	***2***
14.	***Project work***	***1***	***6***
15.	***Comprehensive Viva***	***1***	***3***
16.	Industrial lecture	-	1
17.	NSS / NCC / NSC	-	0
	TOTAL	**17 (Excluding Italics)**	**68**

***including Lab**

****Commence during Orientation Programme**

I. GENERAL INSTITUTE REQUIREMENTS

1. MATHEMATICS

Sl. No.	Course Code	Course Title	Credits
1.	MAIR11	MATHEMATICS I	**4**
2.	MAIR21	MATHEMATICS II	**4**
3.	MAIR32	TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATION	**3**
4.	MAIR41	NUMERICAL TECHNIQUES	**3**
		Total	**14**

2. PHYSICS

Sl. No.	Course Code	Course Title	Credits
1.	PHIR11	PHYSICS I	**3**
2.	PHIR12	PHYSICS II	**4**
		Total	**7**

3. CHEMISTRY

Sl. No.	Course Code	Course Title	Credits
1.	CHIR11	CHEMISTRY I	**3**
2.	CHIR13	CHEMISTRY II	**4**
		Total	**7**

4. HUMANITIES

Sl. No.	Course Code	Course Title	Credits
1.	HSIR13	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	**3**
		Total	**3**

5. COMMUNICATION

Sl. No.	Course Code	Course Title	Credits
1.	HSIR11	ENGLISH FOR COMMUNICATION	3
2.	HSIR12	PROFESSIONAL COMMUNICATION	3
		Total	**6**

6. ENERGY AND ENVIRONMENTAL ENGINEERING

Sl. No.	Course Code	Course Title	Credits
1.	ENIR11	ENERGY AND ENVIRONMENTAL ENGINEERING	2
		Total	**2**

7. PROFESSIONAL ETHICS

Sl. No.	Course Code	Course Title	Credits
1.	HSIR14	PROFESSIONAL ETHICS	3
		Total	**3**

8. ENGINEERING GRAPHICS

Sl. No.	Course Code	Course Title	Credits
1.	MEIR12	ENGINEERING GRAPHICS	3
		Total	**3**

9. ENGINEERING PRACTICE

Sl. No.	Course Code	Course Title	Credits
2.	PRIR11	ENGINEERING PRACTICE	2
		Total	**2**

10. BASIC ENGINEERING

Sl. No.	Course Code	Course Title	Credits
1.	CEIR11	BASIC CIVIL ENGINEERING	2
2.	EEIR11	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	2
		Total	**4**

11. INTRODUCTION TO COMPUTER PROGRAMMING

Sl. No.	Course Code	Course Title	Credits
1.	CSIR11	BASICS OF PROGRAMMING (Theory & Lab)	3
		Total	**3**

12. BRANCH SPECIFIC COURSE

Sl. No.	Course Code	Course Title	Credits
1.	MEIR15	INTRODUCTION TO MECHANICAL ENGINEERING	2
		Total	**2**

13. SUMMER INTERNSHIP

Sl. No.	Course Code	Course Title	Credits
1.	MEIR16	INTERNSHIP / INDUSTRIAL TRAINING / ACADEMIC ATTACHMENT (2 to 3 months duration during summer vacation)	2
		Total	**2**

The student should undergo industrial training/internship for a minimum period of two months during the summer vacation of 3rd year. Attachment with an academic institution within the country (IISc/IITs/NITs/IIITs and CFTIs) or university abroad is also permitted instead of industrial training.

 # To be evaluated at the beginning of VII semester by assessing the report and seminar presentations.

14. PROJECT WORK

Sl. No.	Course Code	Course Title	Credits
1.	MEIR17	PROJECT WORK	6
		Total	**6**

15. COMPREHENSIVE VIVA

Sl. No.	Course Code	Course Title	Credits
1.	MEIR18	COMPREHENSIVE VIVA	3
		Total	**3**

16. INDUSTRIAL LECTURE

Sl. No.	Course Code	Course Title	Credits
1.	MEIR19	INDUSTRIAL LECTURE	**1**
		Total	**1**

A course based on industrial lectures shall be offered for 1 credit. A minimum of five lectures of two hours duration by industry experts will be arranged by the Department. The evaluation methodology, will in general, be based on quizzes at the end of each lecture.

17. NSS / NCC / NSO

Sl. No.	Course Code	Course Title	Credits
1.	SWIR11	NSS / NCC / NSO	**0**
		Total	**0**

(II) PROGRAMME CORE (PC)

[Note: (1) Number of programme core: 16 to 20 (2) Credits: 56 - 65]

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEPC10	ENGINEERING MECHANICS	-NIL-	3
2.	MEPC11	ENGINEERING THERMODYNAMICS	-NIL-	3
3.	MEPC12	STRENGTH OF MATERIALS	-NIL-	3
4.	MEPC13	APPLIED ELECTRICAL AND ELECTRONICS ENGINEERING	EEIR11	4
5.	MEPC14	INSTRUMENTATION AND CONTROL ENGINEERING	-NIL-	3
6.	MEPC16	THERMAL ENGINEERING	MEPC11	3
7.	MEPC17	MECHANICS OF MACHINES - I	MEPC10	3
8.	MEPC18	FLUID MECHANICS	-NIL-	3
9.	MEPC20	ENGINEERING MATERIALS	-NIL-	4
10.	MEPC21	TURBOMACHINES	MEPC18	3
11.	MEPC22	HEAT AND MASS TRANSFER	MEPC11	3
12.	MEPC23	MECHANICS OF MACHINES - II	MEPC17	3
13.	MEPC24	ANALYSIS AND DESIGN OF MACHINE COMPONENTS	MEPC12	3
14.	MEPC25	AUTOMOBILE ENGINEERING	-NIL-	3
15.	MEPC26	DESIGN OF MECHANICAL DRIVES	MEPC12	3
16.	MEPC27	COMPUTER AIDED DESIGN AND DRAFTING	MEIR12	3
17.	MEPC28	POWER PLANT ENGINEERING	MEPC21	3
18.	MEPC29	METROLOGY AND QUALITY CONTROL	-NIL-	3
19.	MEPC30	MANUFACTURING TECHNOLOGY	-NIL-	3
20.	MEPC31	MACHINE DRAWING	MEIR12	3
Total				**62**

(III) ELECTIVES

a. PROGRAMME ELECTIVE (PE)

[Note: Number of programme elective: at least 3 courses]

Students pursuing B.Tech. in Mechanical Engineering should take at least three courses from the Programme Electives listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEPE10	COMPRESSIBLE FLOW AND JET PROPULSION	MEPC18	**3**
2.	MEPE11	COMPUTATIONAL FLUID DYNAMICS	MEPC18	**3**
3.	MEPE12	ADVANCED IC ENGINES	MEPC16	**3**
4.	MEPE13	COMBUSTION ENGINEERING	MEPC16	**3**
5.	MEPE14	BIOFUELS	MEPC16	**3**
6.	MEPE15	REFRIGERATION AND AIR CONDITIONING	MEPC16	**3**
7.	MEPE16	FUNDAMENTALS OF HVAC SYSTEMS	MEPC16	3
8.	MEPE18	NANO TECHNOLOGY	MEPC20	**3**
9.	MEPE19	VEHICLE DYNAMICS	MEPC25	**3**
10.	MEPE21	DYNAMICS OF MACHINERY	MEPC23	**3**
11.	MEPE22	MEMS DEVICES – DESIGN AND FABRICATION	MEPC13	**3**
12.	MEPE24	OIL HYDRAULICS AND PNEUMATICS	MEPC18	**3**
13.	MEPE25	INDUSTRIAL ROBOTICS	MEPC13	**3**
14.	MEPE26	MECHATRONICS	MEPC13	**3**
15.	MEPE27	INDUSTRIAL TRIBOLOGY	MEPC20	**3**
16.	MEPE29	RENEWABLE ENERGY SOURCES	MEPC16	3

b. OPEN ELECTIVE (OE)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MEOE11	FINITE ELEMENT METHOD	-NIL-	**3**
2.	MEOE12	COMPOSITE MATERIALS	-NIL-	**3**
3.	MEOE13	ADVANCES IN WELDING TECHNOLOGY	-NIL-	**3**
4.	MEOE14	INDUSTRIAL SAFETY ENGINEERING	-NIL-	**3**
5.	MEOE15	OPTIMIZATION IN ENGINEERING DESIGN	-NIL-	**3**
6.	MEOE16	CRYOGENIC ENGINEERING	-NIL-	**3**
7.	MEOE17	ENERGY CONSERVATION AND MANAGEMENT	-NIL-	**3**
8.	MEOE18	ENERGY STORAGE TECHNOLOGY	-NIL-	**3**
9.	MEOE19	VEHICLE EMISSIONS AND CONTROL	-NIL-	**3**

c. MINOR (MI)

Students who have registered for B.Tech Minor in Mechanical Engineering.

[Note: Number of Minor courses: 5 courses (Minimum)]

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	MACHINE DESIGN	-NIL-	**3**
6.	MEMI15	FUNDAMENTALS OF AUTOMOTIVE TECHNOLOGY	-NIL-	**3**
7.	MEMI17	FUNDAMENTALS OF REFRIGERATION AND AIR CONDITIONING	-NIL-	**3**
8	MEMI18	PRINCIPLES OF TURBOMACHINERY	-NIL-	3
9	MEMI19	FUNDAMENTALS OF INTERNAL COMBUSTION ENGINES	-NIL-	**3**
10	MEMI20	ENGINE POLLUTION AND CONTROL	-NIL-	**3**
11	MEMI22	DYNAMICS	-NIL-	**3**
12	MEMI23	FUNDAMENTALS OF MECHANICAL DESIGN	-NIL-	**3**

Note : Student should be allowed a minimum of 50% of the total electives of a programme from Open electives and Minor, if so desired by the student.

(IV) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Co requisites	Credits
1.	MELR12	THERMAL ENGINEERING LABORATORY I	MEPC16	**2**
2.	MELR15	DYNAMICS LABORATORY	MEPC23	**2**
3.	MELR16	AUTOMOBILE ENGINEERING LABORATORY	MEPC25	**2**
4.	MELR17	COMPUTER AIDED DESIGN LABORATORY	MEPC27	**2**
5.	MELR18	METROLOGY AND QUALITY CONTROL LABORATORY	MEPC19	**2**
6.	MELR20	SOM/FM LABORATORY	MEPC12/18	**2**
7.	MELR21	MANUFACTURING TECHNOLOGY LAB	MEPC30	**2**
8.	MELR22	THERMAL ENGINEERING LABORATORY II	MEPC22	**2**
Total				**16**

NOTE: Students can register for 2 laboratory courses during one session along with regular courses (PC / PE / OE / MI).

ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

A student can obtain B.Tech. (Honours) degree provided the student has;

i. Registered at least for 12 theory courses and 2 ELRs in the second year.

ii. Consistently obtained a minimum GPA of 8.5 in the first four sessions

iii. Continue to maintain the same GPA of 8.5 in the subsequent sessions (including the Honours courses)

iv. Completed 3 additional theory courses specified for the Honors degree of the programme.

v. Completed all the courses registered, in the first attempt and in four years of study.

Sl. No.	Course Code	Course Title	Pre requisites	Credits
1.	MEHO10	ADVANCED HEAT TRANSFER	MEPC22	**3**
2.	MEHO11	ADVANCED FLUID MECHANICS	MEPC18	**3**
3.	MEHO12	SIMULATION OF IC ENGINES	MEPC16	**3**
4.	MEHO13	DESIGN AND ANALYSIS OF TURBO MACHINES	MEPC21	**3**
5.	MEHO14	ADVANCED ENGINEERING MATERIALS	MEPC20	**3**
6.	MEHO15	DESIGN OF HEAT EXCHANGERS	MEPC22	**3**
7.	MEHO16	DESIGN AND OPTIMIZATION OF THERMAL ENERGY SYSTEMS	MEPC16	**3**

DESCRIPTION OF COURSE CODES FOR B.TECH. PROGRAMME

Sl. No.	Type of the course	Course Code and range
1.	General Institute requirements	xxIR10 to 99
2.	Programme core	xxPC10 to 99
3.	Programme Elective	xxPE10 to 99
4.	Essential Laboratory Requirement	xxLR10 to 99
5.	Open Electives	xxOE10 to 99
6.	Minors	xxMI10 to 99
7.	Honours	xxHO10 to 99

where xx denotes the Department offering the course

DESCRIPTION OF DEPARTMENT CODES FOR B.TECH. PROGRAMME

Sl. No.	Department	Code
1.	Architecture	AR
2.	Chemical Engineering	CL
3.	Civil Engineering	CE
4.	Computer Applications	CA
5.	Computer Science and Engineering	CS
6.	Chemistry	CH
7.	Electronics and Communication Engineering	EC
8.	Electrical and Electronics Engineering	EE
9.	Energy and Environment	EN
10.	Humanities	HM
11.	Instrumentation and Control Engineering	IC
12.	Mathematics	MA
13.	Mechanical Engineering	ME
14.	Metallurgical and Materials Engineering	MT
15.	Production Engineering	PR
16.	Physics	PH
17.	Management Studies (DoMS)	MB
18.	Office of Dean, Student Welfare (NSS/NSC/NSO)	SW

Flow of course for B.Tech. Mechanical Engineering Programme and the session of study for each core course is given below.

Sl. No.	Course Code	Course Title	Year of Study	Session/s
1.	HSIR11	ENGLISH FOR COMMUNICATION	I	July
2.	MAIR11	MATHEMATICS I	I	July
3.	PHIR11	PHYSICS I	I	July
4.	CHIR11	CHEMISTRY I	I	July
5.	CSIR11	BASICS OF PROGRAMMING	I	July
6.	MEIR15	INTRODUCTION TO MECHANICAL ENGINEERING	I	July
7.	CEIR11	BASIC CIVIL ENGINEERING	I	July
8.	EEIR11	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	I	July
9.	PRIR11	ENGINEERING PRACTICE	I	July
10.	HSIR12	PROFESSIONAL COMMUNICATION	I	January
11.	MAIR21	MATHEMATICS II	I	January
12.	PHIR12	PHYSICS II	I	January
13.	CHIR13	CHEMISTRY II	I	January
14.	ENIR11	ENERGY AND ENVIRONMENTAL ENGINEERING	I	January
15.	MEPC10	ENGINEERING MECHANICS	I	January
16.	MEIR12	ENGINEERING GRAPHICS	I	January
17.	SWIR11	NSS/ NCC/ NSO	I	January
18.	MAIR32	TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS	II	July
19.	MEPC11	ENGINEERING THERMODYNAMICS	II	July
20.	MEPC12	STRENGTH OF MATERIALS	II	July
21.	MEPC18	FLUID MECHANICS	II	July
22.	MEPC30	MANUFACTURING TECHNOLOGY	II	July
23.	MEPC31	MACHINE DRAWING	II	July
24.	MELR20	SOM/FM LABORATORY	II	July
25.	MELR21	MANUFACTURING TECHNOLOGY LABORATORY	II	July

26.	MAIR41	NUMERICAL TECHNIQUES	II	January
27.	MEPC13	APPLIED ELECTRICAL AND ELECTRONICS ENGINEERING	II	January
28.	MEPC16	THERMAL ENGINEERING	II	January
29.	MEPC17	MECHANICS OF MACHINES - I	II	January
30.	MEPC27	COMPUTER AIDED DESIGN AND DRAFTING	II	January
31.		ELECTIVE I	II	January
32.	MELR12	THERMAL ENGINEERING LABORATORY I	II	January
33.	MELR13	CADD LABORATORY	II	January
34.	MEPC20	ENGINEERING MATERIALS	III	July
35.	MEPC22	HEAT AND MASS TRANSFER	III	July
36.	MEPC23	MECHANICS OF MACHINES - II	III	July
37.	MEPC24	ANALYSIS AND DESIGN OF MACHINE COMPONENTS	III	July
38.		ELECTIVE-II	III	July
39.		ELECTIVE-III	III	July
40.	MELR14	THERMAL ENGINEERING LABORATORY II	III	July
41.	MELR15	DYNAMICS LABORATORY	III	July
42.	MEPC14	INSTRUMENTATION AND CONTROL ENGINEERING	III	January
43.	MEPC25	AUTOMOBILE ENGINEERING	III	January
44.	MEPC26	DESIGN OF MECHANICAL DRIVES	III	January
45.	MEPC29	METROLOGY AND QUALITY CONTROL	III	January
46.		ELECTIVE-IV	III	January
47.		ELECTIVE-V	III	January
48.	MELR16	AUTOMOBILE ENGINEERING LABORATORY	III	January
49.	MELR17	METROLOGY LABORATORY	III	January
51.	MEIR19	INDUSTRIAL LECTURE	III	January
52.	HSIR	PROFESSIONAL ETHICS	IV	July
53.	MEPC21	TURBOMACHINES	IV	July
54.	MEPC28	POWER PLANT ENGINEERING	IV	July

55.		ELECTIVE-VI	IV	July
56.		ELECTIVE-VII	IV	July
57.		ELECTIVE-VIII	IV	July
58.	MELR16	SUMMER INTERNSHIP	IV	July
59.	MEIR18	COMPREHENSIVE VIVA	IV	July
60.	HSIR13	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	IV	January
61.		ELECTIVE-IX	IV	January
62.		ELECTIVE-X	IV	January
63.		ELECTIVE-XI	IV	January
64.	MEIR17	PROJECT WORK	IV	January

Semester wise curriculum

Semester I

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	HSIR11	English For Communication	-NIL-	3
2.	MAIR11	Mathematics I	-NIL-	4
3.	PHIR11	Physics I	-NIL-	3
4.	CHIR11	Chemistry I	-NIL-	3
5.	CSIR11	Basics of Programming	-NIL-	3
6.	MEIR15	Introduction to Mechanical Engineering	-NIL-	2
7.	CEIR11	Basic Civil Engineering	-NIL-	2
8.	EEIR11	Basic Electrical and Electronics Engineering	-NIL-	2
9.	PRIR11	Engineering Practice	-NIL-	2
	Total Credits			**24**

Semester II

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	HSIR12	Professional communication	-NIL-	3
2.	MAIR21	Mathematics II	-NIL-	4
3.	PHIR21	Physics II	-NIL-	4
4.	CHIR13	Chemistry II	-NIL-	4
5.	ENIR11	Energy And Environmental Engineering	-NIL-	2
6.	MEPC10	Engineering Mechanics	-NIL-	3
7.	MEIR12	Engineering Graphics	-NIL-	3
	Total Credits			**23**

Semester III

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	MAIR32	Transforms and Partial Differential Equations	-NIL-	3
2.	MEPC11	Engineering Thermodynamics	-NIL-	3
3.	MEPC12	Strength of Materials	-NIL-	3
4.	MEPC18	Fluid Mechanics	-NIL-	3
5.	MEPC30	Manufacturing Technology	-NIL-	3
6.	MEPC31	Machine Drawing	MEIR12	3
7.	MELR20	SOM/FM Lab	-NIL-	2
8.	MELR21	Manufacturing Technology Lab	-NIL-	2
	Total Credits			**22**

Semester IV

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	MAIR41	Numerical Methods	-NIL-	3
2.	MEPC13	Applied Electrical and Electronics Engineering	EEIR11	4
3.	MEPC16	Thermal Engineering	-NIL-	3
4.	MEPC17	Mechanics of Machines – I	MEPC10	3
5.	MEPC27	Computer Aided Design and Drafting	MEIR12	3
6.		Elective – I		3
7.	MELR12	Thermal Engineering Lab – I	-NIL-	2
8.	MELR17	CADD Lab	-NIL-	2
	Total Credits			**23**

Semester V

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	MEPC20	Engineering Materials	-NIL-	4
2.	MEPC22	Heat and Mass Transfer	MEPC11	3
3.	MEPC23	Mechanics of Machines – II	MEPC17	3
4.	MEPC24	Analysis and Design of Machine Components	MEPC12	3
5.		Elective – II		3
6.		Elective – III		3
7.	MELR22	Thermal Engineering Lab II	-NIL-	2
8.	MELR15	Dynamics Lab	-NIL-	2
	Total Credits			**23**

Semester VI

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	MEPC14	Instrumentation and Control Engineering	-NIL-	3
2.	MEPC25	Automobile Engineering	-NIL-	3
2.	MEPC26	Design of Mechanical Drives	MEPC12	3
4.	MEPC29	Metrology and Quality Control	-NIL-	3
5.		Elective –IV		3
6.		Elective –V		3
7.	MELR16	Automobile Engineering Lab	-NIL-	2
8.	MELR18	Metrology Lab	-NIL-	2
9.	MEIR19	Industrial Lectures	-NIL-	1
	Total Credits			**23**

Semester VII

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	HSIR14	Professional Ethics	-NIL-	3
2.	MEPC21	Turbomachines	MEPC18	3
3.	MEPC28	Power Plant Engineering	MEPC21	3
4.		Elective – VI	-NIL-	3
5.		Elective – VII	-NIL-	3
6.		Elective – VIII	-NIL-	3
7.	MEIR16	Summer Internship	-NIL-	2
8.	MEIR18	Comprehensive Viva	-NIL-	3
	Total Credits			**23**

Semester VIII

Sl. No.	Course Code	Course Title	Pre requisites	Credits
1.	HSIR13	Industrial Economics and Foreign Trade	-NIL-	3
2.		Elective – IX	-NIL-	3
3.		Elective – X	-NIL-	3
4.		Elective – XI	-NIL-	3
5.	MEIR17	Project Work	-NIL-	6
	Total Credits			**18**

SYLLABUS

I. GENERAL INSTITUTE REQUIREMENTS

1. MATHEMATICS

Course Code	MAIR11
Course Title	MATHEMATICS- I
Number of Credits	4
Prerequisites	-
Course Type	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives:

Objective of the course is to

1. determine canonical form of given quadratic form.
2. discuss the convergence of infinite series.
3. analyze and discuss the extrema of the functions of several variables.
4. evaluate the multiple integrals and apply in solving problems.

Course Content

Characteristic equation of a matrix –Eigen values and Eigen vectors – Properties of Eigen values – Diagonalization of matrix – Cayley-Hamilton Theorem (without proof) verification – Finding Inverse and Power of a matrix using it – Quadratic form – Definite and indefinite forms – Orthogonal reduction of quadratic form to canonical form.

Introduction to sequences, Infinite series - Convergence Tests for positive term series – Comparison, integral test, Root, Ratio test, Raabe's tests, logarithmic test - Alternating series – Leibnitz's rule – Absolute and Conditional Convergence. Riemann rearrangement theorem (without proof).

Functions of several variables – Partial derivatives and Transformation of variables – Jacobian and its Properties- Taylor series-Maxima and Minima of function of two variables.

Double integral – Changing the order of Integration – Change of variables from Cartesian to Polar Coordinates – Area using double integral in Cartesian and Polar Coordinates – Triple integral – Change of Variables from Cartesian to Spherical and Cylindrical Coordinates – Volume using double and triple integrals.

Course Outcomes:

After the completion of the course, students would be able to

1. compute eigenvalues and eigenvectors of the given matrix.
2. transform given quadratic form into canonical form.
3. discuss the convergence of infinite series by applying various test.
4. compute partial derivatives of function of several variables
5. write Taylor's series for functions with two variables.
6. evaluate multiple integral and its applications in finding area, volume.

Reference Books

1. Kreyszig, E., Advanced Engineering Mathematics, 10th edn, John Wiley Sons, 2010.
2. Grewal, B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publications, Delhi.
3. Greenberg, M.D. Advanced Engineering Mathematics, Second Edition, Pearson Education Inc. 1998.
4. Strauss. M.J, Bradley, G.L. and Smith, K.J. Calculus, 3rd Edition, Prentice Hall, 2002.

Course Code	MAIR21
Course Title	MATHEMATICS – II
Number of Credits	4
Prerequisites	MAIR11
Course Type	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives:

Objective of the course is to

1. Introduce the structure vector space and various operations on it.
2. Introduce different method to solve the 2nd order differential equations and its applications in electric circuit problems.
3. familiarize concepts like differentiations and integration for function of complex variable.
4. Introduce vector differential operator for vector function and important theorems on vector functions to solve engineering problems.

Course Content

Vector space – Subspaces – Linear dependence and independence – Spanning of a subspace – Basis and Dimension. Inner product – Inner product spaces – Orthogonal and orthonormal basis – Gram- Schmidt orthogonalization process.

Basic review of first order differential equation - Higher order linear differential equations with constant coefficients – Particular integrals for $x^n e^{ax}, e^{ax}\cos(bx), e^{ax}\sin(bx)$ – Equation reducible to linear equations with constant coefficients using $x = e^t$ - Simultaneous linear equations with constant coefficients – Method of variation of parameters – Applications – Electric circuit problems.

Gradient, Divergence and Curl – Directional Derivative – Tangent Plane and normal to surfaces – Angle between surfaces –Solenoidal and irrotational fields – Line, surface and volume integrals – Green's Theorem, Stokes' Theorem and Gauss Divergence Theorem (all without proof) – Verification and applications of these theorems.

Analytic functions – Cauchy – Riemann equations (Cartesian and polar) –Properties of analytic functions – Construction of analytic functions given real or imaginary part – Conformal mapping of standard elementary functions $\left(z^2, e^z, \sin z, \cos z, z + \frac{k^2}{z}\right)$ and bilinear transformation.

Cauchy's integral theorem, Cauchy's integral formula and for derivatives– Taylor's and Laurent's expansions (without proof) – Singularities – Residues – Cauchy's residue theorem – Contour integration involving unit circle.

Course Outcomes:

After the completion of the course, students are able to

1. Perform standard operation in finite dimensional vector spaces
2. Compute the dot product of vectors, lengths of vectors, and angles between vectors.
3. Perform gradient, div, curl operator on vector functions and give physical interpretations.
4. Use Green's , Gauss divergence and Stoke's theorems to solve engineering problems.
5. solve higher order ODEs and interpret it geometrically.
6. Compute differentiation of functions of complex variable.
7. Construct analytic function for given real or imaginary part of it.
8. find images of the given region by standard functions of complex variable.
9. compute bilinear map by knowing the images of three points.

Reference Books:

1. Kreyszig, E., Advanced Engineering Mathematics, 10th edn, John Wiley Sons, 2010.
2. Grewal, B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publications, Delhi.
3. Gilbert Strang, Linear Algebra and its applications, 4th edn, Cengage Learning, 2006
4. James Ward Brown and Ruel V. Churchill, Complex variables and Applications, 9th edn, McGraw-Hill, 2013

Course Code	MAIR32
Course Title	TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS
Number of Credits	3
Prerequisites	MAIR11, MAIR21
Course Type	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

students completing this course will be able to

1. understand the importance of transform techniques to solve engineering problems.
2. apply Laplace and Fourier transform to solve the mathematical equations arising in mechanical engineering.
3. understand Fourier series analysis and its use in solving boundary value problems.
4. understand and solve the partial differential equations.
5. construct mathematical model of some heat transfer problem and vibration of an elastic string.

Course Content

Laplace Transform of Standard functions, derivatives and integrals – Inverse Laplace transform - Convolution theorem-Periodic functions – Application to ordinary differential equations and simultaneous equations with constant
coefficients and integral equations.

Fourier series - Dirichlet's conditions - Half range Fourier cosine and sine series - Parseval's relation - Fourier series in complex form – Harmonic analysis.

Fourier transforms - Fourier cosine and sine transforms – inverse transforms - convolution theorem and Parseval's identity for Fourier transforms - Finite cosine and sine transforms.

Formation of partial differential equations eliminating arbitrary constants and functions - solution of first order equations - four standard types - Lagrange's equation - homogeneous and non-homogeneous type of second order linear differential equation with constant coefficients.

One-dimensional wave equation and one-dimensional heat flow equation - method of separation of variables - Fourier series solution.

Course outcomes:

completion of the course, students should be able to

1. Compute Laplace and inverse Laplace transform of functions.
2. Apply Laplace transform to solve ordinary differential equations.
3. Compute Fourier and inverse Fourier transform of functions.
4. Compute Fourier series of given function and interpret its coefficients.
5. Able to form partial differential equation for given family of surfaces.
6. Compute solution of few types of linear and non-linear first order/second order PDEs.
7. Construct mathematical model of heat transfer problem and its solution by separation of variable method.
8. Construct mathematical model of vibration of elastic sting (one dimensional) and solution of it.

Reference Books:

1. Grewal.B.S., Higher Engineering Mathematics, 43rdEdition, Khanna Publisher, Delhi
2. Debnath L., and Dambaru Bhatta, Integral Transforms and Their Applications, 2nd Ed. (Special Indian Ed).Chapman & Hall/CRC, Indian Edtion, 2010
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2010.
4. Haberman R., Applied Partial Differential Equations: With Fourier Series and Boundary Value Problems. Pearson, 2013.
5. K.Sankara Rao, Introduction to Partial Differential Equations, 3rd Edn, PHI Learning Private Ltd. 2012.

Course Code:	MAIR41
Course Title:	NUMERICAL TECHNIQUES
Number of Credits:	3
Prerequisites:	MAIR11, MAIR21, MAIR31/MAIR32
Course Type:	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives: To introduce

1. Numerical Methods for Solving Linear Systems
2. Methods to solve equations of One Variable as well as system of equations with two variables.
3. Interpolating Polynomials and best curve fitting methods for the given data.
4. Numerical Differentiation and Integration
5. Numerical Solutions of Ordinary Differential Equations
6. Numerical Methods to solve partial differential equations.

Course Content

Solution of linear system - Gaussian elimination and Gauss-Jordan methods - LU - decomposition methods - Crout's method - Jacobi and Gauss-Seidel iterative methods - sufficient conditions for convergence - Power method to find the dominant eigenvalue and eigenvector.

Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton-Raphson method for f(x) = 0 and for f(x,y) = 0, g(x,y) = 0 - Order of convergence - Horner's method - Graeffe's method - Bairstow's method.

Newton's forward, backward and divided difference interpolation – Lagrange's interpolation – Numerical Differentiation and Integration – Trapezoidal rule – Simpson's 1/3 and 3/8 rules - Curve fitting - Method of least squares and group averages.

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method - Taylor's method and Runge-Kutta method for simultaneous equations and 2nd order equations - Multistep methods - Milne's and Adams' methods.

Numerical solution of Laplace equation and Poisson equation by Liebmann's method - solution of one dimensional heat flow equation - Bender - Schmidt recurrence relation - Crank - Nicolson method - Solution of one dimensional wave equation.

Course Outcomes:

completion of the course, students should be able to

1. compute numerical solution of given system AX=B by direct and iterative methods.
2. compute largest eigenvalue and its corresponding eigenvector of matrix A.
3. compute numerical solution of f(x)=0 and nonlinear equations with two variables,
4. interpolate function and approximate the function by polynomial.
5. compute numerical differentiation and integration of $f(x)$.
6. compute best curve fit for the given data by curve fitting method.
7. compute numerical solution of ordinary differential equations by finite difference method.
8. compute numerical solution of partial differential equations by finite difference method.

Reference Books:

1. David Kincaid and Ward Cheney, Numerical Analysis\, 3rd edition, American Mathematics Society, (Indian edition) – 2010.
2. Gerald C.F., and Wheatley P.O., Applied Numerical Analysis, Addison-Wesley Publishing Company, 1994
3. Jain, M.K., Iyengar, S.R. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age international,2003
4. Atkinson, K.E., An Introduction to numerical Analysis, John Wiley & Sons, 2008

2. PHYSICS

Course Code	**:**	PHIR11
Course Title	**:**	PHYSICS I
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. To introduce the notions of light matter interaction, fabrication of lasers, light propagation in waveguides, applications of lasers and optical fibers.
2. To understand the fundamentals of acoustics, crystal physics and structure determination of crystals.
3. To learn the fundamentals of magnetic, electrical and superconducting materials.
4. To introduce the thoughts of special theory of relativity.

Course Content

Lasers
Introduction to Laser-characteristics of Lasers-Spontaneous and stimulated emissions – Einstein's coefficients – population inversion and lasing action – laser systems: Ruby laser, He-Ne Laser, semiconductor laser-applications- Holography.

Fiber Optics
Fermat's principle and Snell's law-optical fiber – principle and construction – acceptance cone - numerical aperture – V-Number - types of fibers, Fabrication: Double Crucible Technique – fiber optic communication principle – fiber optic sensors.

Acoustics
Introduction -reverberation – reverberation time – Sabine's formula – acoustics of buildings – ultrasonics – production of ultrasonics using piezoelectric method –magnetostriction method-applications.

Crystallography

Seven crystal systems and Bravais lattices– Miller indices – interplanar distance-–symmetry operation -Bragg's law of X-ray diffraction –Laue Method- powder crystal method- structure determination for cubic system.

Magnetic materials, conductors and superconductors

Magnetic materials: Definition of terms – classification of magnetic materials and properties – domain theory of ferromagnetism- hard and soft magnetic materials – applications.
Conductors: classical free electron theory (Lorentz –Drude theory) – electrical conductivity
Superconductors: definition – Meissner effect – type I & II superconductors – BCS theory (qualitative) – high temperature superconductors – Josephson effects applications.

Special theory of relativity

Lorentz transformation -Time dilation – length contraction- mass-energy relation.

Course Outcomes

Students will be able to know principle, construction of lasers, light propagation in optical fibers and their applications. Students will understand the acoustics of building, ultrasonics, crystal systems and structure determination. Students will also appreciate various materials properties like electrical, magnetic and superconducting. Students will also establish mass-energy relationship through special theory of relativity.

References

1. Laser Fundamentals, William T. Silfvast, 2nd edn, Cambridge University press, New York (2004)
2. Fundamentals of Physics, 6th Edition, D. Halliday, R. Resnick and J. Walker, John Wiley and Sons, New York (2001).
3. Introduction to solid state physics,7th Edn, Charls Kittel, Wiley, Delhi (2007) 4. Concepts of Modern Physics. Arthur Beiser, Tata McGraw-Hill, New Delhi (2010).
5. Fundamentals of Physics, R. Shankar, Yale University Press, New Haven and London (2014).

Laboratory Experiments

1. Torsional pendulum
2. Numerical aperture of an optical fiber
3. Temperature measurement - Thermocouple
4. Specific rotation of a liquid – Half Shade Polarimeter
5. Thickness of a thin wire – Air Wedge
6. Conversion of galvanometer into ammeter and voltmeter
7. Dispersive power of a prism – Spectrometer
8. Superconductivity- measurement of transition temperature
9. Kundt's tube experiment

References

1. Physics Laboratory Manual, Department of Physics, National Institute of Technology Tiruchirappalli (2018).
2. Practical Physics, R.K. Shukla, Anchal Srivastava, New age international (2011).
3. B.Sc. Practical Physics, C.L Arora, S. Chand &Co. (2012).

Course Code	**:**	PHIR12
Course Title	**:**	PHYSICS II
Number of Credits	**:**	4
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. To introduce the concepts of matter waves, wave functions and its interpretation to understand the matter at atomic scale.

2. To understand the fundamentals of nuclear forces, models and classification of matter.

3. To know the basics of advanced materials and their applications.

4. To introduce the concepts of NDT, vacuum pumps and their applications.

Course Content

Quantum Mechanics
Inadequacy of classical mechanics (black body radiation, photoelectric effect, Compton effect) – wave and particle duality of radiation – de Broglie concept of matter waves – electron diffraction – Heisenberg's uncertainty principle – Schrodinger's wave equation – eigen values and eigen functions – superposition principle – interpretation of wave function – particle confined in one dimensional infinite square well potential.

Nuclear and Particle Physics
Nuclear properties and forces - Nuclear models - Shell model - Nuclear reaction - Radioactivity - types and half-lives - Stellar nucleosynthesis. Fundamental forces - Particle physics - classification of matter - quark model - neutrino properties and their detection.

Advanced Materials
Nanomaterials: introduction and properties – synthesis – chemical vapour deposition – ball milling – applications. Carbon nanotubes: structure and properties – synthesis– arc method – pulsed laser deposition- applications.
Liquid Crystals: types – nematic, cholesteric, smectic – modes: dynamic light scattering, twisted nematic – display systems.
Shape memory alloys-one way and two-way memory effect- pseudoelasticity-applications.

Non-Destructive Testing
Liquid penetrant testing – magnetic particle inspection- principle of ultrasonic testing – inspection methods – pulse-echo, through transmission-different types of scans — principle and types of radiography – exposure factor – attenuation of radiation – real time radiography – principle of thermography – thermographic camera – advantages and limitations.

Vacuum Technology

Introduction- -classification of pumps-rotary vane pump-roots pump-diffusion pump-turbo-molecular pump-measurement of low pressure-pirani gauge-penning gauge - applications of vacuum technology - thin film deposition: thermal evaporation.

Course Outcomes

Students will be able to experience the behaviour of matter at atomic scale, role of nuclear and particle physics in applications like radioactivity and nuclear reactions. Students will also get an exposure to nanomaterial synthesis, liquid crystal display and shape memory alloys. Students will also familiarize various NDT methods, vacuum pumps and their applications.

References

1.Concepts of Modern Physics. Arthur Beiser, Tata McGraw-Hill, New Delhi (2010).
2.Fundamentals of Physics II, R. Shankar, Yale University Press, New Haven and London (2016).
3.Hand Book of Non-destructive evaluation, C.J. Hellier, McGraw-Hill, New York (2001).
4.Vacuum Science and Technology, V.V. Rao, T.B. Ghosh, K.L. Chopra, Allied Publishers, New Delhi (2008).
5.Introduction to Nanotechnology, C.P. Poole and F.J. Owens, Wiley, New Delhi (2007).
6. Introduction to Liquid Crystals Chemistry and Physics, 2nd Ed, Peter J. Collings, Princeton University Press, New Jersey, (2002).
7. Shape memory alloys - modeling and engineering applications, Ed. D. C. Lagoudas, Springer, New York (2008).

3. CHEMISTRY

Course Code	**:**	CHIR11
Course Title	**:**	CHEMISTRY I
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. To introduce the students to basic principles of chemical bonding, coordination chemistry, reaction mechanism, stereochemical aspects of organic compounds.
2. To provide a brief outline on the types and applications of polymers.

Course Content

Chemical Bonding

Basic concepts of bonding and applications: VBT, VSEPR theory, MO Theory. Intermolecular interactions-ion ion interactions, ion-dipole interactions, hydrogen bonding, dipole-dipole interactions, London / dispersion forces, relative strength of intermolecular forces; Consequences-surface tension.

Coordination and Organometallic Chemistry

Coordination Chemistry: Crystal field theory, Octahedral, Tetrahedral & Square planar complexes, Jahn-Teller Distortion, Color, magnetism, EAN Rule, 18 electron Rule, Wilkinson Catalysis, Zieglar-Natta Catalysis, Boranes & Wades rules (the closo-, nido-, arachno- borane structural paradigm, Wade-Mingos and Jemmis electron counting rules) Dioxygen transport and storage-hemoglobin and myoglobin.

Basic organic reactions and mechanism

Nucleophilic substitution reactions: SN^1, SN^2, SN^i mechanism. Elimination reaction: The E1, E2 and E1cB mechanisms, Hofmann versus Saytzeff elimination, Pyrolytic syn-elimination. Oxidation reaction: with peracids, $Pb(OAc)_4$, OsO_4, SeO_2. Reduction reactions: reduction with hydride transfer reagents like $NaBH_4$, $LiAlH_4$ and DIBAL-H. Birch reduction.

Stereochemistry & Aromaticity

Representations of three dimensional structures - Types of Isomerism - configurations and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Applications of chirality in drug molecules. Aromaticity, Huckels rule of aromaticity and anti-aromaticity, annulenes, heteroannulenes.

Polymers and Composites

Concept of macromolecules-Nomenclature of polymers-Tacticity- Polymerization processes-Mechanism-Types of Polymerization-Classification of Polymers-Effect of Polymer structure on properties-Moulding of plastics into articles-Important addition and condensation polymers – synthesis and properties – Molecular mass determination of polymers- Static and dynamic methods, Light scattering and Gel Permeation Chromatography-Rubbers –Vulcanization – Synthetic rubbers – Conducting polymers-Composite materials – Reinforced composites and processing.

Course Outcome

Students will learn about the fundamentals and needs of chemical bonding, coordination chemistry, polymers and composites. They will be familiarizing with basics of reaction mechanism and stereochemical aspects of organic molecules.

Practical (Laboratory Experiments):

1. Determination of reaction kinetics of hydrolysis of an ester.
2. Estimation of carbonate, non-carbonate and total hardness in the given water sample.
3. Percentage purity of bleaching powder.
4. Determination of the percentage of Fe in the given steel sample.
5. Estimation of Ca in limestone.
6. Estimation of Fe^{3+} by spectrophotometer.

Course Outcome

The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn to determine the reaction kinetics, estimate various components from corresponding bulk mixture.

Reference Books

1. PW Atkins and J de Paula, Physical Chemistry by, Oxford University Press.
2. Inorganic Chemistry: Principles of Structure and Reactivity, J E Huheey, E A Keiter, R L Keiter and O K Medhi, 4 th Edn, 2006, Pearson, ISBN: 006042995X.
3. Organic Chemistry, Paula Y Bruice, 7th Edition, Springer, 2009, Pearson. ISBN-13: 978-0321819031.

Course Code	**:**	CHIR13
Course Title	**:**	CHEMISTRY II
Number of Credits	**:**	4
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

To introduce the students to basic principles of electrochemistry, cell construction and evaluation, corrosion, adsorption, phase equilibrium and engineering materials of importance

Course Content

Unit-I: Electrochemistry

Conductivity of electrolytes- Specific, molar and equivalent conductivity, Nernst equation for electrode potential, EMF series, hydrogen electrode, calomel electrode, glass electrode, Electrolytic and galvanic cells, cell EMF, its measurement and applications, Weston standard cell, reversible and irreversible cells, concentration cell, electrode (hydrogen gas electrode) and electrolyte concentration cell, concentration cell with and without transference, fuel cells, hydroxy fuel cell.

Unit-II: Corrosion

Dry corrosion and wet corrosion, mechanisms, types of corrosion, DMC, DAC, stress, inter granular, atmospheric and soil corrosion, Passivity, Polarization, over potential and its significance, Factors affecting corrosion, protection from corrosion by metallic coatings, electroplating, electroless plating and cathodic protection, Chemical conversion coatings and organic coatings- Paints, enamels.

Unit-III: Surface Chemistry

Adsorption – types – adsorption of gases on solids – adsorption isotherm – Freundlich and Langmuir isotherms – adsorption of solutes from solutions – role of adsorbents – activated carbon in pollution abatement of air and waste water. Phase rule: Statement and explanation of the terms involved – one component water system – condensed phase rule – construction of phase diagram by thermal analysis – simple eutectic systems (Pb - Ag system only) – alloys – importance, ferrous alloys – nichrome, and stainless steel, nonferrous alloys – brass and bronze – heat treatment of alloys.

Unit-IV: Engineering Materials

Abrasives – Moh's scale of hardness – natural abrasives (diamond, corundum, emery, garnets and quartz) – synthetic abrasives (silicon carbide, boron carbide) – refractories – characteristics – classification (acidic, basic and neutral refractories) – properties (refractoriness, refractoriness under load, dimensional stability, porosity, thermal spalling) – manufacture of alumina magnesite and zirconia bricks. Cement - Important Parameters for Manufacturing Cement Clinkers. Chemical Constituents and Composition of Cement. Methods of Manufacture of Cement - Wet and Dry Processes. Additives for Cement. Properties of Cement - Setting and Hardening. Types of Portland cement.

Unit-V: Polymers and Composites

Concept of macromolecules-Nomenclature of polymers-Tacticity- Polymerization processes-Mechanism-Types of Polymerization-Classification of Polymers-Effect of Polymer structure on properties-Moulding of plastics into articles-Important addition and condensation polymers – synthesis and properties – Molecular mass determination of polymers- Static and dynamic methods, Light scattering and Gel Permeation Chromatography-Rubbers –Vulcanization – Synthetic rubbers – Conducting polymers Composite materials – Reinforced composites and processing.

Laboratory Experiments

1. Corrosion rate by polarization technique
2. Conductometric titration
3. Potentiometric titration
4. pH metric titration
5. Percentage purity of bleaching powder
6. Percentage purity of washing soda
7. Determination of molecular weight of polymer by viscometry
8. Demonstration of sophisticated instruments and assignments on them

Reference Books:

1. F.W. Billmayer. 'Textbook of Polymer Science', 3rd Edn, Wiley. N.Y. 1991.
2. S. S. Dara, S. S. Umare, 'A Text Book of Engineering Chemistry', S. Chand Publishing, 2011

Course Outcomes

At the end of the course student will learn the significance of electrochemistry and its application, corrosion, adsorption, engineering materials of importance and polymer.

4. HUMANITIES

Course Code	**:**	HSIR13
Course Title	**:**	INDUSTRIAL ECONOMICS AND FOREIGN TRADE
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. Give a simple yet thorough introduction into the main methods of economic analysis of industry structure and firm behaviour under various conditions of technology, competition, and organization.
2. Elaborate students' skills and abilities to use modern theoretical and empirical tools to formulate and solve economic problems.
3. Explore in details how economists approach and answer specific empirical questions.

Course Content

Demand and Supply – Forecasting techniques – Cost and Revenues.

Competitive nature of the firms – Keynesian economics – National income.

International Trade – Meaning and Benefits – Basis of International Trade – Foreign Trade and Economic Growth – Balance of Trade – Balance of Payment – Current Trends in India – Barriers to International Trade – WTO – Indian EXIM Policy.

Foreign Exchange Markets – Spot Prices and Forward Prices – Factors influencing Exchange rates – The effects of Exchange rates in Foreign Trade – Tools for hedging against Exchange rate variations – Forward, Futures and Currency options – FEMA – Determination of Foreign Exchange rate and Forecasting

Exchange Rate determination – Marketing – Product life cycle – Marketing research – Branding – Personality – Motivation – Leadership – Working in Teams.

References:

1. Adhikary Manab, Business Economics, Excel Books, 2004.
2. Dwivedi, D.N., Macro Economics Theory & Policy, Tata Mc Graw-Hill, 2005.
3. Aczel D. Amir, Soundarapandian Jayavel, Complete Business Statistics, Tata Mc Graw-Hill, 2005.
4. Robins P. Stephen, Organizational Behaviour, Prentice-Hall, 2002.
5. Apte P.G., International Financial Management, Tata McGraw Hill, 2011.
6. Jeff Madura, International Corporate Finance, Cengage Learning, 9th Edition, 2011.

Course Outcomes:

At the end of the course student will be able to
1. Analyze the risk of decision making in a firm.
2. Describe and explain the determinants of the size and structure of firms.
3. Give an overview of trade cycle, inflation, cash flow analysis and Balance sheet.
4. Explain the marketing research, product life cycle, motivation and leadership.
5. Describe the competitive nature of the firm and team working.

5. COMMUNICATION

Course Code	**:**	HSIR11
Course Title	**:**	ENGLISH FOR COMMUNICATION
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

The primary objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for academic and social needs.

Course Content

An introduction - Its role and importance in the corporate world – Tools of communication – Barriers – Levels of communication – English for Specific purposes and English for technical purposes.

Listening process & practice – Exposure to recorded & structured talks, class room lectures – Problems in comprehension & retention – Note-taking practice – Listening tests- Importance of listening in the corporate world.

Introduction of different kinds of reading materials: technical & non-technical – Different reading strategies: skimming, scanning, inferring, predicting and responding to content – Guessing from context – Note making – Vocabulary extension.

Barriers to speaking – Building self-confidence & fluency – Conversation practice- Improving responding capacity - Extempore speech practice – Speech assessment.

Effective writing practice – Vocabulary expansion - Effective sentences: role of acceptability, appropriateness, brevity & clarity in writing – Cohesion & coherence in writing –Writing of definitions, descriptions & instructions - Paragraph writing - Introduction to report writing.

Reference Books:

1. Krishna Mohan and Meenakshi Raman ’Effective English Communication’, Tata McGraw Hill, New Delhi, 2000.
2. Meenakshi Raman and Sangeetha Sharma ‘Technical Communication’, Oxford University Press, New Delhi, 2006.
3. M. Ashraf Rizvi ‘Effective Technical Communication’, Tata McGraw-Hill, New Delhi, 2005.
4. Golding S.R. ‘Common Errors in English Language’, Macmillan, 1978.
5. Christopher Turk ‘Effective Speaking’, E & FN Spon, London, 1985.

Course Outcomes

At the end of the course student will be able to express themselves in a meaningful manner to different levels of people in their academic and social domains.

Course Code	**:**	HSIR12
Course Title	**:**	PROFESSIONAL COMMUNICATION
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

The primary objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for their professional needs.

Course Content

Listening Barriers to listening: Physical & psychological – Steps to overcome them – Purposive listening practice – Active listening and anticipating the speaker – Use of technology in the professional world.

Speaking Fluency & accuracy in speech – Positive thinking – Kinds of thinking -Improving self-expression – Tonal variations – Listener oriented speaking -Group discussion practice – Interpersonal Conversation -Developing persuasive speaking skills.

Reading Speed reading practice – Use of extensive readers –Trans-coding: verbal and nonverbal – Eye-reading practice – Analytical and critical reading practice- Introduction to ethics & values through case-study materials.

Writing Professional Correspondence – Formal and informal letters – Argument Writing practice – Perspectives in writing – Narrative writing -Different registers - Tone in formal writing – Summary writing practice- Introduction to reports.

Study Skills Reference Skills - Use of dictionary, thesaurus etc – Importance of contents page, cover & back pages – Bibliography.

Reference Books:

1. Shirley Taylor (1999), 'Communication for Business', Longman, New Delhi.
2. Robert Gannon (2000), 'Best Science Writing: Readings and Insights', University Press, Hyderabad.
3. Richard A. Boning (1990), 'Multiple Reading Skills', McGraw Hill, Singapore.
4. Albert J. Harris, Edward R.Sipay (1990), 'How to Increase Reading Ability', Longman.
5. David Martin (1994), 'Tough Talking', University Press, Hyderabad.

Course Outcomes

At the end of the course student will be able to get knowledge of the various uses of English in their professional environment and they will be able to communicate themselves effectively in their chosen profession.

6. ENERGY AND ENVIRONMENTAL ENGINEERING

Course Code	**:**	ENIR11
Course Title	**:**	ENERGY AND ENVIRONMENTAL ENGINEERING
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. To teach the principal renewable energy systems.
2. To explore the environmental impact of various energy sources and also the effects of different types of pollutants.

Course Content

Present Energy resources in India and its sustainability - Different type of conventional Power Plant--Energy Demand Scenario in India-Advantage and Disadvantage of conventional Power Plants – Conventional vs Non-conventional power generation

Basics of Solar Energy- Solar Thermal Energy- Solar Photovoltaic- Advantages and Disadvantages-Environmental impacts and safety.

Power and energy from wind turbines- India's wind energy potential- Types of wind turbines- Off shore Wind energy- Environmental benefits and impacts.

Biomass resources-Biomass conversion Technologies- Feedstock preprocessing and treatment methods- Bioenergy program in India-Environmental benefits and impacts. Geothermal Energy resources –Ocean Thermal Energy Conversion – Tidal.

Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water pollution-Sources and impacts, Soil pollution-Sources and impacts, disposal of solid waste.

Greenhouse gases – effect, acid rain. Noise pollution. Pollution aspects of various power plants. Fossil fuels and impacts, Industrial and transport emissions- impacts.

Reference Books:

1. Boyle, G. 2004.' Renewable energy: Power for a sustainable future'. Oxford University Press.
2. B H Khan, 'Non-Conventional Energy Resources'-The McGraw –Hill Second edition.
3. G. D. Rai, 'Non-conventional energy sources', Khanna Publishers, New Delhi, 2006.
4. Gilbert M. Masters, 'Introduction to Environmental Engineering and Science', 2nd Edition, Prentice Hall, 2003.
5. 'Unleashing the Potential of Renewable Energy in India' –World Bank report.
6. Godfrey Boyle, Bob Everett and Janet Ramage.2010. 'Energy Systems and Sustainability. Power for a sustainable future'. Oxford University Press.

Course Outcomes

At the end of the course student will be introduced to the Principal renewable energy systems and explore the environmental impact of various energy sources and also the effects of different types of pollutants.

7. PROFESSIONAL ETHICS

Course Code	**:**	HSIR14
Course Title	**:**	PROFESSIONAL ETHICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. Identify the core values that shape the ethical behavior of an engineer
2. To create an awareness on professional ethics and Human Values
3. To appreciate the rights of others

Course Content

Morals, Values and Ethics - Integrity - work Ethic - Service Learning - Civic Virtue - Respect for others - Living peacefully - Caring - Sharing - Honesty - Courage - Valuing time - Co-operation - Commitment - Empathy - Self-Confidence - Character - Spirituality - The role of engineers in modern society - social expectations.

Sense of 'Engineering Ethics' - Variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - Consensus and controversy - Models of Professional Roles & Professionalism - theories about right action - Self-interest - customs and religion - uses of ethical theories.

Engineering as experimentation - engineers as responsible experimenters - Research ethics - Codes of ethics - Industrial Standard - Balanced outlook on law - the challenger case study.

Safety and risk - assessment of safety and risk - Riysis - Risk benefit analysis and reducing risk - Govt. Regulator's approach to risks - the three mile island and Chernobyl case studies & Bhopal - Threat of Nuclear power, depletion of ozone, greenery effects - Collegiality and loyalty - respect for authority - collective bargaining - Confidentiality - conflicts of interest - occupation crime - professional rights - employees' rights - Intellectual Property rights (IPR) - discrimination.

Multinational corporations - Business ethics - Environmental ethics - computer ethics - Role in Technological Development - Weapons development engineers as managers - consulting engineers - engineers as expert witnesses and advisors - Honesty - leadership - sample code of

conduct ethics like ASME, ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management Institution of electronics and telecommunication engineers (IETE), India, etc.,.

Reference books:

1. Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw Hill, New York (2005).
2. Charles E Harris, Michael S Pritchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Thompson Learning, (2000).
3. Charles D Fleddermann, "Engineering Ethics", Prentice Hall, New Mexico, (1999).
4. John R Boatright, "Ethics and the Conduct of Business", Pearson Education, (2003)
5. Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers", Oxford University Press, (2001)
6. Prof. (Col) P S Bajaj and Dr. Raj Agrawal, "Business Ethics – An Indian Perspective",
7. Biztantra, New Delhi, (2004)

Course Outcome

At the end of the course student will be able to
1. Understood the core values that shape the ethical behaviour of an engineer
2. Exposed awareness on professional ethics and human values.
3. Known their role in technological development

8. ENGINEERING GRAPHICS

Course Code	**:**	MEIR12
Course Title	**:**	ENGINEERING GRAPHICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. Irrespective of engineering discipline, it has become mandatory to know the basics of Engineering Graphics. The student is expected to possess the efficient drafting skill depending on the operational function in order to perform day to day activity.
2. Provide neat structure of industrial drawing
3. Enables the knowledge about position of the component and its forms Interpretation of technical graphics assemblies
4. Preparation of machine components and related parts

Course Content

Fundamentals Drawing standard - BIS, dimensioning, lettering, type of lines, scaling-conventions.
Geometrical constructions Dividing a given straight line into any number of equal parts, bisecting a given angle, drawing a regular polygon given one side, special methods of constructing a pentagon and hexagon – conic sections – ellipse – parabola – hyperbola - cycloid– trochoid.
Orthographic projection Introduction to orthographic projection, drawing orthographic views of objects from their isometric views - Orthographic projections of points lying in four quadrants,

Orthographic projection of lines parallel and inclined to one or both planes Orthographic projection of planes inclined to one or both planes. Projections of simple solids - axis perpendicular to HP, axis perpendicular to VP and axis inclined to one or both planes.

Sectioning of solids Section planes perpendicular to one plane and parallel or inclined to other plane.

Intersection of surfaces Intersection of cylinder & cylinder, intersection of cylinder & cone, and intersection of prisms.

Development of surfaces Development of prisms, pyramids and cylindrical & conical surfaces. **Isometric and perspective projection** Isometric projection and isometric views of different planes and simple solids, introduction to perspective projection.

Computer aided drafting Introduction to computer aided drafting package to make 2-D drawings.

Reference Books:

1. Bhatt, N. D. and Panchal, V.M., 'Engineering Drawing', Pub.: Charotar Publishing House, 2010.
2. Natarajan, K. V., 'A text book of Engineering Graphics', Pub.: Dhanalakshmi Publishers, Chennai, 2006.
3. Venugopal, K. and Prabhu Raja, V., 'Engineering Drawing and Graphics + AutoCAD', Pub.: New Age International, 2009.
4. Jolhe, D. A., 'Engineering drawing', Pub.: Tata McGraw Hill, 2008
5. Shah, M. B. and Rana, B. C., 'Engineering Drawing', Pub.: Pearson Education, 2009.
6. Trymbaka Murthy, S., 'Computer Aided Engineering Drawing', Pub.: I.K. International Publishing House, 2009.

Course Outcomes

At the end of the course student will be able to visualize the engineering components. A number of chosen problems will be solved to illustrate the concepts clearly.

9. ENGINEERING PRACTICE

Course Code	**:**	PRIR11
Course Title	**:**	ENGINEERING PRACTICE
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

Introduction to the use of tools and machinery in Carpentry, Welding, Foundry, Fitting and Sheet Metal Working.

Course Content

Carpentry
Wood sizing exercise in planning, marking, sawing, chiseling and grooving to make
1. Half lap joint
2. Cross lap joint

Welding
Exercise in arc welding for making
1. Lap joint
2. Butt joint

Foundry
Preparation of sand mould for the following
1. Flange
2. Anvil

Fitting
Preparation of joints, markings, cutting and filling for making
1. V-joint
2. T-joint

Sheet metal
Making of small parts using sheet metal
1. Tray
2. Funnel

Course Outcome

At the end of the course student will be able to
1. To provide hands on exercises in common carpentry works associated with residential and industrial buildings.
2. To expose the students regarding pipe connection for pumps & turbines and to study the joint used in roofs, doors, windows and furnitures.
3. To provide hands on exercise on basic welding, machining and sheet metal works.
4. To provide exposure regarding smithy, foundry operations and in latest welding operations such as TIG, MIG, CO2, spot welding etc.

10. BASIC ENGINEERING

Course Code	**:**	CEIR11
Course Title	**:**	BASIC CIVIL ENGINEERING
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Objectives

• To give an overview of the fundamentals of the Civil Engineering fields to the students of all branches of Engineering

• To realize the importance of the Civil Engineering Profession in fulfilling societal needs

Course Content

Introduction to Engineering Seismology, Properties and uses of construction materials - stones, bricks, cement, concrete and steel.

Site selection for buildings - Component of building - Foundation- Shallow and deep foundations - Brick and stone masonry - Plastering - Lintels, beams and columns - Roofs.

Structural Systems and Recent Developments, Roads-Classification of Rural and urban Roads-Pavement Materials-Traffic signs and Road Marking-Traffic Signals.

Surveying - Classification-Chain Survey-Ranging-Compass Survey-exhibition of different survey equipment.

Sources of Water - Dams- Water Supply-Quality of Water-Wastewater Treatment – Sea Water Intrusion – Recharge of Ground Water.

Course Outcome

1. The students will gain knowledge on site selection, construction materials, components of buildings, roads and water resources
2. A basic appreciation of multidisciplinary approach when involved in Civil Related Projects.

Reference Books

1. Punmia, B.C, Ashok Kumar Jain, Arun Kumar Jain*, 'Basic Civil Engineering',* Lakshmi Publishers, 2012.
2. Satheesh Gopi, 'Basic Civil Engineering', Pearson Publishers, 2009.
3. Rangwala, S.C, *'Building materials',* Charotar Publishing House, Pvt. Limited, Edition 27, 2009.
4. Palanichamy,M.S*, 'Basic Civil Engineering',* Tata Mc Graw Hill, 2000.
5. Lecture notes prepared by Department of Civil Engineering, NITT.

Course Code	**:**	EEIR11
Course Title	**:**	BASICSOF ELECTRICALANDELECTRONICS ENGINEERING
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

1. This course aims to equip the students with a basic understanding of Electrical circuits and machines for specific types of applications.
2. The course gives a comprehensive exposure to house wiring.
3. This course also equips students with an ability to understand basics of analog and digital electronics.

Course Content

DC & AC Circuits: Current, voltage, power, Kirchhoff's Laws - circuit elements R, L and C, phasor diagram, impedance, real and reactive power in single phase circuits.

DC & AC Machines: DC Motor, Induction motor, Synchronous motor, Synchronous generator and Transformers- construction, principle of operation, types and applications.

House wiring & safety: Single phase and three phase system – phase, neutral and earth, basic house wring - tools and components, different types of wiring – staircase, fluorescent lamp and ceiling fan, basic safety measures at home and industry.

Analog Electronics: semiconductor devices – p-n junction diode, Zener diode, BJT, operational amplifier – principle of operation and applications – Introduction to UPS.

Digital Electronics: Introduction to numbers systems, basic Boolean laws, reduction of Boolean expressions and implementation with logic gates.

Reference Books:

1. Hughes revised by Mckenzie Smith with John Hilcy and Keith Brown, 'Electrical and Electronics Technology', 8th Edition, Pearson, 2012.
2. R.J. Smith, R.C. Dorf, 'Circuits Devices and Systems', 5th Edition, John Wiley and sons, 2001.
3. P. S. Dhogal, 'Basic Electrical Engineering – Vol. I & II', 42nd Reprint, Mc Graw Hill, 2012.
4. Malvino, A. P., Leach D. P. and Gowtham Sha, 'Digital Principles and Applications', 6th Edition, Tata Mc Graw Hill, 2007.
5. Vincent Del Toro, 'Electrical Engineering Fundamental', Prentice Hall India, 2002.

Course Outcome

At the end of the course, students will be able to develop an intuitive understanding of the circuit analysis, basic concepts of electrical machines, house wiring and basics of electronics and be able to apply them in practical situation.

11. INTRODUCTION TO COMPUTER PROGRAMMING

Course Code	**:**	CSIR12
Course Title	**:**	BASICS OF PROGRAMMING (Theory & Lab)
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

1. To learn the fundamentals of computers.
2. To learn the problem solving techniques writing algorithms and procedures.
3. To learn the syntax and semantics for C programming language
4. To develop the C code for simple logic
5. To understand the constructs of structured programming including conditionals and iterations

Course Content

Introduction to computers – Computer Organization – Characteristics – Hardware and Software – Modes of operation – Types of programming languages – Developing a program.

Algorithms – Characteristics – Flowcharts - Principles of Structured programming – Sequential, selective structures - Repetitive structures –Bounded , Unbounded and Infinite iterations – Examples for each.

Introduction to C – C character set – Identifiers and Keywords – Datatypes – Constants – Variables – Declarations – Expressions – Statements – Symbolic constants – Operators– Library functions – Data input and output: Single character input and output – Entering input data – Writing output data – gets and puts functions. Control statements – Branching: if-else – Looping: while – do-while – for; Nested control structures – switch statement – break statement – continue statement – comma operator – goto statement.

Modular Programming – Functions and Procedures – Examples – Parameter passing methods.

Arrays – Defining an array – Processing an array – Multidimensional arrays-Pointers – Variable definitions and initialization – Pointer operators – Pointer expressions and arithmetic – Pointers and one-dimensional arrays- Functions – Defining a function – Accessing a function – Function prototypes – Passing arguments to a function –Passing arrays to a function – Passing pointers to a function – Recursion.

Laboratory Experiments

1. Programs using sequence construct
2. Programs using selection construct
3. Programs using Iterative construct
4. Programs using nested for loops
5. Programs using functions with Pass by value
6. Programs using functions with Pass by reference
7. Programs using recursive functions
8. Programs using one dimensional Array
9. Programs using two dimensional Arrays
10. Programs using Pointers and functions
11. Programs using Pointers and Arrays

Reference Books:

1. Byron Gottfried, ‘Programming with C’, Third Edition, Tata McGraw Hill Education, 2010.
2. R.G.Dromey, ‘How to Solve it By Computers?’, Prentice Hall, 2001
3. J.R. Hanly and E.B. Koffman, ‘Problem Solving and Program Design in C’, 6th Edition,
4. Pearson Education, 2009.

5. Paul Deital and Harvey Deital, 'C How to Program', Seventh Edition, Prentice Hall, 2012.
6. Yashavant Kanetkar, 'Let Us C', 12th Edition, BPB Publications, 2012.

Course Outcome

At the end of the course, student will be
1. Ability to write algorithms for problems
2. Knowledge of the syntax and semantics of C programming language
3. Ability to code a given logic in C language
4. Knowledge in using C language for solving problems

12. BRANCH SPECIFIC COURSE

Course Code	**:**	MEIR15
Course Title	**:**	INTRODUCTION TO MECHANICAL ENGINEERING
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

1. To introduce and define the basics concept of mechanical engineering.
2. To familiarize the working principles of IC engines and automobile systems.
3. To enable the students to understand the details about the energy systems and its components.
4. To demonstrate the various machine elements, materials and its function.
5. To help the students acquire knowledge about the various manufacturing process.

Course Content

Introduction to Mechanical Engineering, Thermal Engineering, Design, manufacturing Engineering. Role and Responsibilities of a Mechanical Engineers

IC Engines – 2 Stroke and 4 stroke systems in IC Engines. Automobiles - Transmission systems, Suspension system, ABS, Airbag Systems, E-Vehicles.

Energy Systems - Power plants, Types, Gas Turbines, Steam Turbines, Utility boilers, R & A/C system- Green Energy production and Devices – Fluid Movers, Pumps and Compressors

Engineering materials, Machine elements and its functions

Manufacturing, Classification, Metal forming, Casting, Lathe, drilling machines, Milling machines, Metal joining, Additive Manufacturing.

Course Outcomes
At the end of the course, students will be able

1. To identify the basic concept and fundamentals of mechanical engineering.
2. To understand the working principle of IC engines and Energy systems.

3. To appreciate the process and materials involved in the manufacture of various machine element components.

Reference Books:

1. Lecture notes prepared by Department of Mechanical Engineering, NITT.
2. K. Venugopal, 'Basic mechanical Engineering' ISBN: 9788187721291, Anuradha Agencies Pub-Chennai, 2014

13. SUMMER INTERNSHIP

Course Code	**:**	MEIR16		
Course Title	**:**	INTERNSHIP/INDUSTRIA/TRAINING/ACADEMIC		
		ATTACHMENT (2 to 3 Months duration during summer vacation)		
Number of Credits	**:**	2		
Prerequisites	**:**	-NIL-		
(Course code)				
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**		

Course Learning Objective

1. To provide undergraduate engineering students with hands-on exposure to industry facilities, thereby furthering their understanding of the basics and operations of sciences and its applications
2. During the assignment period, students apart from technical exposure, will also learn to work in teams that possess diverse knowledge and skills; experience project management; develop time management; and most importantly learn to understand rules and regulations as well as adhere to policies and procedures.
3. Students' communication and presentation skills are expected to improve after the internship period as a result of constant contacts with mentors and administrative personnel.
4. Students must make the best use of this opportunity to apply their theoretical background in engineering learned at the PI to solve design and maintenance problems and demonstrate an awareness of current and future engineering applications in the industry.

Course Outcome

At the end of the course, students will be
1. An ability to function on multi-disciplinary teams.
2. An ability to identify, formulate and solve engineering problems.
3. An understanding of professional and ethical responsibility.
4. An ability to communicate effectively with written, oral and visual means.
5. The broad education necessary to understand the impact of engineering solution in a global and society context.
6. A recognition of the need for and ability to engage in life-long learning.

14. PROJECT WORK

Course Code	**:**	MEIR17
Course Title	**:**	PROJECT WORK
Number of Credits	**:**	6
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2. To train the students in preparing project reports and to face reviews and viva voce examination.

Course Outcome

At the end of the course student will
1. Identify real world problems of mechanical engineering and related systems.
2. Interpret the working of mechanical engineering systems.
3. Apply the principles of mechanical engineering in real world systems.
4. Criticize and experiment to arrive at solutions for real world mechanical engineering problems.
5. Analyse and evaluate to obtain solution for problems in mechanical engineering systems.

15. COMPREHENSIVE VIVA

Course Code	**:**	MEIR18
Course Title	**:**	COMPREHENSIVE VIVA
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objectives

1. The objective of the comprehension exam is to attain an understanding of the concepts of simultaneous manufacturing systems including materials, fabrication process, product and process control, manufacturing with computer and quality management.
2. The students work in groups and solve different types of problems/ activities given to them.
3. The activities given to the students should be real time like problems in industries chosen by a team of faculty members of the concerned department.
4. A minimum of three small problems have to be solved by each group of students
5. The evaluation is based on continuous assessment by group of faculty members constituted by the professor in-charge of the course.

Course Outcomes

Recall, recognize, visualize, illustrate, demonstrate, criticize and appraise the aspects of mechanical engineering systems and the interaction among them.

16. INDUSTRIAL LECTURE

Course Code	**:**	MEIR19
Course Title	**:**	INDUSTRIAL LECTURE
Number of Credits	**:**	1
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

1. To provide hands-on training to truly appreciate the various fields of mechanical engineering related concepts.
2. Invited talks from industry experts are planned to further enrich the course.

Course Outcome

At the end of the course, student skills, personal, exposure and knowledge will be developed.

17. NSS/NCC/NSO

Course Code	**:**	SWIR11
Course Title	**:**	NSS/ NCC/ NSO
Number of Credits	**:**	0
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**GENERAL INSTITUTE REQUIREMENTS**

Course Learning Objective

To enable the students to gain knowledge about NCC/NSS/NSO/YOGA and put the same into practice

Course Content

National Cadet Corps (NCC)
Any student enrolling as a member of National Cadet Core (NCC) will have to attend sixteen parades out of twenty parades each of four periods over a span of academic year. Attending eight parades in first semester will qualify a student to earn the credits specified in the curriculum. Grading shall be done based on punctuality, regularity in attending the parades and the extent of active involvement.

National Service Scheme (NSS)
A student enrolling as member of NSS will have to complete 60 hours of training / social service to be eligible to earn the credits specified in the curriculum. Grading shall be done by the faculty member handling the course based on punctuality, regularity in attending the classes and the extent of active involvement.

National Sports Organization (NSO)

Each student must select one of the following games/sports events and practice for one hour per week. An attendance of 75% is compulsory to earn the credits specified in the curriculum. Grading shall be done by the faculty member handling the course based on punctuality, regularity in attending the classes and the extent of active involvement. List of games/sports: Basket Ball, Football, VolleyBall, Ball Badminton, Cricket, Throw-ball, Track events Field events or any other game with the approval of faculty member.

Course Outcome

To imbibe in the minds of students the concepts and benefits of NCC/NSS/NSO/YOGA and make them practice the same

II. PROGRAMME CORE (PC)

Course Code	**:**	MEPC10
Course Title	**:**	ENGINEERING MECHANICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To explain the importance of mechanics in the context of engineering and conservation equations
2. To explain the significance of centroid, center of gravity and moment of inertia.
3. To introduce the techniques for analyzing the forces in the bodies.
4. To analyze the internal member forces acting on cables and trusses.
5. To understand the basic principles of dynamics.

Course Content

Fundamentals: Mechanics and its relevance, concepts of forces, laws of mechanics – Lami's Theorem, Concept of free-body diagram, centroids, center of gravity, area moment of inertia, mass, moment of inertia.

Statics: Principles of statics, Types of forces, concurrent and non-concurrent forces, composition of forces, forces in a plane and space, simple stresses and strains, elastic constant.

Friction: Laws of friction, application of laws of friction, wedge friction, body on inclined planes.

Dynamics: Principles of dynamics, D'Alembert's principle, conservation of momentum and energy.

Reference Books:

1. Timoshenko S, and Young D.H, 'Engineering Mechanics', Tata McGraw Hill, 2006.

2. Shames I.H, and Rao G.K.M, 'Engineering Mechanics – Static and Dynamics', Pearson Education, 2009.
3. Beer F.P and Johnson Jr.E.R, 'Vector Mechanics for Engineers', Tata McGraw Hill, 2009.

Course Outcomes

The terminal objectives of the course is that, on successful completion of teaching-learning and evaluation activities, a student would be able to identify and analyze the problems by applying the fundamental principles of engineering mechanics and to proceed to research, design and development of various engineering systems.

Course Code	**:**	MEPC11
Course Title	**:**	ENGINEERING THERMODYNAMICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To learn the principles of work and energy.
2. To acquire knowledge about the fundamentals of thermodynamic laws, concepts and principles.
3. 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

Review of basic concepts of thermodynamics, properties of pure substances - First law applied to control mass, control volumes. Steady flow energy equation (SFEE) - applications of SFEE - Uniform state, Uniform flow- Zeroth law of thermodynamics and temperature scales.

Second law statements - irreversible processes, Carnot theorem, Clausius Inequality — Entropy, Entropy change for pure substances – T-S diagram, Entropy change applied to control mass, control volume-Availability and irreversibility.

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

Thermodynamic relations : Partial derivatives - Maxwell relations - Clapeyron equation, Internal energy, Enthalpy, Entropy, Specific heat general relations Behavior of real gases - Equations of state. Generalized Compressibility Chart and its use.

Mixture of non-reacting gases - Dalton's and Amalgam's model - Calculation of C_p , C_v , R, u, h and s changes for gas mixtures. Fuels and combustion - Combustion chemistry - Calculation of air fuel ratio - Exhaust gas analysis.

Reference Books:

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.

Course Outcomes

At the end of the course student will

1. Define the fundamentals of the first and second laws of thermodynamics and explain their application to a wide range of systems.
2. Analyze the work and heat interactions associated with a prescribed process path and to perform analysis of a flow system.
3. Evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.

Course Code	**:**	MEPC12
Course Title	**:**	STRENGTH OF MATERIALS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To develop the theoretical basis about the stress, strain and elastic modulus concepts in various components.
2. To understand the mechanical behavior of materials.
3. To familiarize the student in calculating shear force, bending moment, deflection and slopes in various types of beams for different loading conditions
4. To solve practical problems related to springs and shafts.

Course Content

Axial and shear stresses and strains – Elasticity, Hook's law – Lateral strain – Poisson's ratio – Volumetric strain – Elastic constants – Stress in composite bars. Strain energy impact and suddenly applied loads.

Thin cylindrical and spherical shells subjected to internal pressure. Principal stresses and their planes. Plane of maximum shear – Mohr's circle of stresses. Thick cylinders – Lame's equation, shrink fit. Compound cylinders.

Shear force and bending moment diagrams for beams subjected to different types of loads – Theory of simple bending and assumptions.

Leaf spring, shear stress. Deflection – The moment area method, Macaulay's method – superposition (statically determinate beams only).

Torsion of solid and hollow circular shafts – Power transmission, strength and stiffness of shafts. Stress and defection in open helical spring.

Reference Books:

1. Timoshenko, S.P., Gere, M.J., Mechanics of Materials, C.B.S., Publishers, 1980.
2. Ramamurtham, S., Strength of Materials,, Dhanpat Rai Publications, 2005.
3. Popov, E.P., Engineering Mechanics of Solids, Prentice-Hall, 1999.

Course Outcomes

At the end of the course student will

1. Analyse and design structural member subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behaviour of materials.
2. Present the concept of shear force, bending moment, slope and deflection and their use in machine design.
3. Understand the mohr's circle and be able to determine principle stresses.
4. Calculate the stresses and strain associated with thin wall spherical & cylindrical pressure vessels and types of springs.

Course Code	**:**	MEPC18
Course Title	**:**	FLUID MECHANICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MAIR21
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To familiarize with the properties of fluids and the applications of fluid mechanics.
2. To formulate and analyze problems related to calculation of forces in fluid structure interaction.
3. To classify flows and to understand and apply the conservation principles for fluid flows.
4. To understand the principles of dimensional analysis.
5. To familiarize students with the relevance of fluid dynamics to many engineering systems

Course Content

Introduction: Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, 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, stream lines, path lines, streak lines, stream tubes, velocity and acceleration in fluid, circulation and vorticity, stream function and potential function, Laplace equation, equipotential lines flow nets, uses and limitations.

Dynamics of Fluid flow: Fluid Dynamics: Energies in flowing fluid, head, pressure, dynamic, static and total head, Control volume analysis of mass, momentum and energy, RTT, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof), Bernoulli's equation and its applications, Velocity measurements: Pitot tube and Pitot-static tube.

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.

Concept of Boundary Layer : 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. Dimensional Analysis and Hydraulic similitude: Dimensional analysis, Buckingham's theorem, important dimensionless numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach numbers, Applications and limitations of model testing, simple problems only.

Reference Books:

1. Fox, R.W. and Mc Donald, A.T., Introduction to Fluid Mechanics, 6th ed., John Wiley, 2003.
2. White, F.M., Fluid Mechanics, 5th ed., McGraw-Hill, 2003.
3. Yungus A. Cengel, John Cimbala, Fluid Mechanics Fundamental and applications, 3rd ed. Tata McGraw-Hill Education.
4. S. K. Som, Gautam Biswas, Suman Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, 3rd ed. Tata McGraw-Hill Education.

Course Outcomes

At the end of the course student will be able to
1. Calculate pressure variations in accelerating fluids using Euler's and Bernoulli's equations
2. Become conversant with the concepts of flow measurements and flow through pipes
3. Apply the momentum and energy equations to fluid flow problems.
4. Evaluate head loss in pipes and conduits.
5. Use dimensional analysis to design physical or numerical experiments and to apply dynamic similarity

Course Code	**:**	MEPC30
Course Title	**:**	MANUFACTURING TECHNOLOGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	NIL
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To learn the various methods and types of castings, welding processes, sheet metal forming, plastics.
2. To impart knowledge on selection of suitable manufacturing process for the typical component.
3. To understand the working of machine tools such as lathe, shaper, planner, slotter, milling, hobbing, and grinding.
4. To know the basic concepts of NC and CNC machine tool programming and additive manufacturing processes

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 equipments - 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

Course Outcomes

At the end of the course student will be able to
1. Recognize the different types of casting and welding process.
2. Explain the concept of forging, rolling process and drawing.
3. Explain the features and applications of various machining processes.
4. Recognize the knowledge of NC & CNC Part programming and Additive Manufacturing process

Reference Books:

1. Jain R.K., Production Technology, Khanna Publishers, 2001.
2. Hajra Choudhry, Elements of Workshop Technology, Vol – II Media Promoters & Publishers, 1994.
3. Production Technology by HMT, Tata McGraw-Hill, 2002.
4. Chapman, W.A.J., Workshop Technology, Vol - II, Oxford & IBH Publishing Co. Ltd., 1986. Course

6. Khanna, O.P., and Lal, M., A Text Book of Production Technology, Vol II, Dhanpat Rai & Sons, 1992.
7. Yoram Koren, Computer Control of Manufacturing Systems, McGraw-Hill, 1986.
8. Choudhry, S.K.H., Elements of Work Shop Technology, Vol II, Media Promoters & Publishers, 1994.
9. Kundra, T.K., Rao. P.N., and Tiwari, N.L.K., Numerical Control and Computer Aided Manufacturing, Tata McGraw-Hill, 2006.
10. Serope Kalpakjian; Steven R.Schmid (2010), Manufacturing Engineering and Technology, 6th Edition, Publisher: Prentice Hall, ISBN-10 0 13 – 608168-1.
11. Ian Gibson, David W.Rosen, Brent Stucker, Additive manufacturing technologies; rapid prototyping to direct digital manufacturing, Springer,2010

Course Code	**:**	MEPC31
Course Title	**:**	MACHINE DRAWING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEIR12
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To understand and apply national and international standards while drawing machine component.
2. To understand the concept of various tolerances and fits used for component design
3. To familiarize in drawing assembly, orthographic and sectional views of various machine components.

Course Content

Standardization - Interchangeability - Selective Assembly - Tolerance. Tolerance of form and position - grades of tolerance - fits -Standard tolerances - Machining symbols - surface finish indication - Functional and manufacturing datum.

Shaft Couplings: rigid, flexible: cotter joints, knuckle joints, Hook's joints. Bearings - Journal - Footstep, thrust or Collar bearing; Plummer block; Pulleys for flat belts, V-belt and rope.

Engine parts - Stuffing box, Connecting rod, Atomizer, spark plug, fuel injection pump. Valves - stop valve- safety valve, relief valve and non-return valve. Machine tool components - Drill jig, Tail stock,

Tool post, Tool head for shaping machine, machine vice, screw jack.

Reference Books:

1. Dhawan, R.K., A Text Book of Machine Drawing, S. Chand & Company, 1996.
2. Ostrowsky, O., Engineering Drawing with CAD Applications, ELBS, 1995.
3. Engineering Drawing Practice for Schools and Colleges SP**:** 46- 1988.

Course Outcomes

At the end of the course student will

1. Identify the national and international standards pertaining to machine drawing.
2. Apply limits and tolerances to assemblies and choose appropriate fits.
3. Recognize machining and surface finish symbols.
4. Explain the functional and manufacturing datum.
5. Illustrate various machine components through drawings

Course Code	**:**	MEPC13
Course Title	**:**	APPLIED ELECTRICAL AND ELECTRONICS ENGINEERING
Number of Credits	**:**	4
Prerequisites (Course code)	**:**	EEIR11
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To provide the key concepts about AC motors and thereby able to choose the appropriate drives for various applications.
2. To equip students to understand and apply the basic concepts of control techniques used for drives in industries and to appraise the implementation of various control circuits

Course Content

Prerequisites: Basic Electrical and Electronics Engineering

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.
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

Reference Books:

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
2. Ramesh S. Gaonkar, 'Microprocessor Architecture Programming and Applications with 8085', Penram Intl. Publishing, 6th edition, 2013.
3. Morris Mano, Michael D Ciletti, 'Digital Design', Pearson Education, 4th edition, 2008.
4. Theraja B L,'A TextBook of Electrical Technology', vol 2,S Chand,23rd edition,2007.
5. Vincent Del Toro, 'Electrical Engineering Fundamentals', PHI, 2nd edition, 2009.
6. Subrahmanyan V, 'Thyristor control of Electric Drives', Tata McGraw Hill, 1st edition.

Course Outcomes

At the end of the course student will be able to

1. Analyze the performance of AC motors under various operating conditions using their various characteristics.
2. Choose appropriate motor for various applications in industries
3. Design and analyze combinational logic circuits.
4. Understand the architecture and instruction set of 8085.
5. Analyse the various control logics for industrial drive applications

Course Code	**:**	MEPC16
Course Title	**:**	THERMAL ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC11
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To familiarize with the types of working principle of two stroke and four stroke engines.
2. To understand the various parameters involved in Engine combustion and its significance
3. To provide knowledge on various steam power equipment and its performance measurements
4. To impart skills to analyse Air Compressor system and components
5. To understand the concepts of waste heat recovery systems and thermal measurement devices.

Course Content

Classification of IC engines – Working of two and four stroke engines – Valve and Port timing diagrams – Comparison of air and fuel standard cycles – Performance and heat balance test on IC engines, Fuel supply system – Simple and complete Carburetors –Fuel injector system – Engine cooling, Lubrication, Ignition systems – Fuels for IC engines.

Combustion in SI engines – Combustion in CI engines – Engine exhaust emissions and air pollution – Emissions control technique– Low temperature combustion.

Compressors – Classification of compressors– Performance of reciprocating air compressor – Effect of clearance volume – Multi stage reciprocating air compressor – Optimum intermediate pressure for perfect inter cooling – Compressor mean effective pressure.

Refrigerants - Vapour compression refrigeration cycle- Super heat – Sub cooling – Performance calculations - Vapour absorption system - Ammonia water, Lithium bromide water.

Psychrometric process-Air conditioning system – Working principles and concept of RSHF, GSHF, ESHF- Cooling Load calculations.

Reference Books:

1. Ganesan, V., Internal Combustion Engines, Tata McGraw-Hill, 2003.
2. Heywood, J.B., Fundamentals of Internal Combustion Engines, McGraw-Hill, 1988.
3. Ballaney, P.L., Thermal Engineering, Khanna Publishers, 1996.
4. Arora.C.P, Refrigeration and Air Conditioning, Tata McGraw-Hill Publishers 1994.
5. Roy, J. Dossat, Principles of Refrigeration, Wiley Eastern Ltd., New Delhi, 2000.

Course Outcomes At the end of the course student will:

1. Apply principles of Air standard cycle to improve the engine performance and select suitable emission control methods for real time.
2. Perform tests on steam power thermal devices as per standards and interpret results.
3. Analyze the performance of Air compressor and select suitable intercooling system.
4. Appraise the refrigeration cycles and perform cooling load calculations for air-conditioning system.
5. Identify the suitable waste heat recovery methods for various thermal applications and analysis the energy losses using thermal measurement device.

Course Code	**:**	MEPC17
Course Title	**:**	MECHANICS OF MACHINES – I
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC10
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To impart knowledge on various types of Mechanisms and synthesis
2. To impart skills to analyse the position, velocity and acceleration of mechanisms
3. 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

Introduction to animation software: working model

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

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

Reference Books:

1. Robert L. Norton.," Design of Machinery: an introduction to synthesis and analysis of mechanisms and machines" 5th ed.,McGraw-Hill 2012
2. Uicker,J.J., Jr., Pennock,G.R., and Shigley, J.E., Theory of Machines and Mechanisms ,3rd ed., Oxford University Press,2003.
3. Robert Norton., "Kinematics and Dynamics of machinery" 1st ed.,McGraw Hill India., 2009

Course Outcomes

At the end of the course student will
1. Synthesize and analyze 4 bar mechanisms
2. Use computers for mechanism animation and analysis
3. Understand cams and gears

Course Code	**:**	MEPC27
Course Title	**:**	COMPUTER AIDED DESIGN AND DRAFTING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEIR12
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To introduce the student to the basic tools of computer-aided design (CAD) and computer-aided manufacturing (CAM).
2. To expose the student to contemporary computer design tools for aerospace and mechanical engineers.
3. To prepare the student to be an effective user of a CAD/CAM system.

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.

Reference Books:

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.

Course Outcomes

At the end of the course student will
1. Explain lifecycle of a product and the role of computer-aided design (CAD) in product development.
2. Describe the concepts of geometric and solid modelling.
3. Visualize geometric models through animation and transform them into real world systems.

Course Code	**:**	MEPC20
Course Title	**:**	ENGINEERING MATERIALS
Number of Credits	**:**	4
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To impart knowledge on the atomic arrangement and structure of metals and alloys.
2. To acquire sound knowledge on phase diagram and heat treatment of materials.
3. To understand the various material testing methods.

Course Content

Atomic Arrangement and Phase Diagrams - Structure of metals and alloys: Phase diagram: phase rules.

Phase Diagrams and Ferrous Alloys Fe- FeC diagram, Critical temperature - Plain carbon steel and other steels. .

Heat Treatment of steel, CCT diagrams, austempering, martempering ausforrning. Surface hardening process - non – copper, aluminum base alloys.

Testing of Materials I - Properties evaluated by tensile testing procedure, Engineering stress strain curve vs. true stress-strain curve, stress strain curve for typical materials. Hardness testing.

Testing of Materials II - Impact testing, Fracture toughness. Fatigue testing: Creep testing.

Laboratory Experiments

Metallography specimen preparation

Optical microscopy (micro structure evaluation of cast iron, carbon steel. stainless steel and alloy steels)

Mechanical Characterization of materials- Tensile testing, Impact testing and Hardness testing

Reference Books:

1. Avner, S.H., Introduction to Physical Metallurgy, 2nd ed., Tata McGraw-Hill, 1997.
2. Dieter, G.E.,Mechanical Metallurgy, McGraw-Hill, 1988.
3. Donald S.Clark, and Wilbur R. Varney, Physical Metallurgy for Engineers, East-West Press, 1999.
4. Suriyanarayana, A.V.K, Testing of metallic materials, Tata McGraw-Hill, 2001.

Course Outcomes

At the end of the course student will
1. Interpret the atomic arrangement and structure of metals and alloys.
2. Describe the iron-carbon equilibrium diagram and phase diagrams.
3. Explain the behavior of material upon heat treatment from iron-carbon equilibrium diagram and predict the behavior of materials upon impact, fracture and creep testing.

Course Code	**:**	MEPC22
Course Title	**:**	HEAT AND MASS TRANSFER
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC11
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To learn the various modes of heat transfer and understand the basic concepts of mass transfer.
2. To understand the applications of various experimental heat transfer correlations in engineering applications.
3. To discuss the thermal analysis and sizing of heat exchangers.

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 - Green house effect.

Boiling and condensation – pool boiling regimes and correlations – crictical 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

Reference Books:

1. Bergman T.L., Lavine A.S., Incropera, F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley, 2011.
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. Sachedva, R.C., Fundamentals of Heat and Mass Transfer, 4th ed., New Age International, 2012.

Course Outcomes

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

1. Explain the real time applications of heat transfer in both solids and fluids.
2. Describe the fundamentals of natural and forced convective heat transfer processes.
3. Design the heat exchange equipment.
4. Explore the real time applications of radiation mode of heat transfer.
5. Relate the mass transfer concepts for various industrial applications.

Course Code	**:**	MEPC23
Course Title	**:**	MECHANICS OF MACHINES – II
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC17
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To impart knowledge about dynamic analysis of mechanisms and balancing
2. To familiarize about gyroscopes and flywheels
3. To give understanding various aspects of mechanical vibrations and their control

Course Content

Static and inertial force analysis of mechanisms. Balancing: rotating masses in single and several planes- reciprocating masses- single and multi-cylinder engines-Lanchester balancer

Gyroscopes: Gyroscopic effect- gyroscopes and their uses

Flywheel: industrial uses of flywheels- design of a flywheel of IC engines and punch press

Mechanical vibrations: linear and torsional vibrations- two rotor, three rotor and multi rotor systems- damped vibrations- 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

Reference Books:

1. George H. Martin., "Kinematics and Dynamics of Machines" 2nd ed., Waveland Pr Inc., 2002
2. Morrison.J.L.M., Crossland.B., "An Introduction to the Mechanics of Machines" 1st ed., Longmans, 1964
3. Daniel J. Inman., " Engineering Vibrations" 3rd ed., Pearson Education 2009
4. R.L. Norton, Kinematics & Dynamics of Machinery (Sie), Tata McGraw-hill, 2009.
5. J. Keith Nisbett and Richard G. Budynas Shigley's, "Mechanical Engineering Design" Tata McGraw-hill, 2014

Course Outcomes

At the end of the course student will
1. Perform static and dynamic analysis of mechanisms
2. Understand the issues related to balancing of reciprocating and rotating machinery
3. Know the working of gyroscopes and flywheels
4. Have understanding about the effect of vibration and vibration control

Course Code	**:**	MEPC24
Course Title	**:**	ANALYSIS AND DESIGN OF MACHINE COMPONENTS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC12
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To familiarize the various steps involved in the Design Process
2. To understand the principles involved in evaluating the shape and dimensions of a component
3. To satisfy functional and strength requirements.
4. To learn to use standard practices and standard data
5. To learn to use catalogues and standard machine components

Course Content

Mechanical engineering design - Design considerations - Material selection - Modes of failure - Theories of failure - Endurance limit - Stress concentration - Factor of safety.

Design of shafts and couplings - Design of cotter and knuckle joints.

Helical and leaf springs.

Fasteners and keys - Design of welded joints - Fillet and butt welds - Design of riveted joints.

Design of sliding contact bearings - Selection of rolling contact bearings.

Reference Books:

1. Sundararajamoorthy, T.V. and Shanmugam, N., Machine Design, Anuradha Agencies, 2003.
2. Shigley, J.E., Charles, R.M. and Richard, G.B., Mechanical Engineering Design, 7th ed., McGraw-Hill, 2004.
3. R. N. Norton, "Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines". 5th ed., McGraw-Hill, 20011.

Course Outcomes

At the end of the course student will

1. Describe the design process, material selection, calculation of stresses and stress concentrations under variable loading.
2. Design the solid, hollow shafts and to finding the critical speeds.
3. Differentiate between rigid and flexible couplings and also the knuckle joints.
4. Analyze bolted joints in eccentric loading.
5. Examine the welded joints for vessels and steel structures also have a design knowledge on sliding and rolling contact bearing.
6. Summarize the knowledge in helical, leaf, disc and torsional springs and also in levers.

Course Code	**:**	MEPC14
Course Title	**:**	INSTRUMENTATION AND CONTROL ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To discuss the generalized instrumentation system and calibration of instruments.
2. To describe the status and dynamic characteristics of instruments
3. To analyze the error and uncertainty propagation of instruments
4. To recall principles and analysis of measurement systems used for measurement of flow, power, pressure and temperature
5. To explain the basics of control systems

Course Content

Generalized instrumentation system – Error theory – Calibration of instruments – Range – resolution – Span – Linearity, Sensitivity – Signal conditioning systems.

Static and dynamic characteristics of instruments zero order, first order, second order instruments.

Error analysis – Uncertainty propagation – Oscilloscope for analysis of dynamic and transient events.
Principles and analysis of measurement systems used for measurement of flow, power, pressure and temperature.

Basics of control system – Types of control – proportional control, Derivative control, Integral control, PID control – Programmable Logic Controllers.

Reference Books:

1. Doebelin, E.O., Measurement Systems – Application and Design, 5th ed., McGraw-Hill, 2004.
2. Beckwith, T.G., Buck, L. and Marangoni, R.D., Mechanical Measurements, Narosa Pub. House, 1987.
3. Hewlett Packard, Practical Temperature Measurements – Application Note 290, 1995.

Course Outcomes

At the end of the course student will be able to

1. To discuss the generalized instrumentation system and calibration of instruments
2. To describe static and dynamic characteristics of instruments
3. To analyze the error and uncertainty propagation of instruments
4. To recall principles and analysis of measurement systems used for measurement of flow, power, pressure and temperature
5. To explain the basics of control system.

Course Code	**:**	MEPC25
Course Title	**:**	AUTOMOBILE ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To study basic and advanced automotive systems and subsystems.
2. To impart knowledge on the construction and principle of operation of in automotive engine and auxiliary systems.
3. To Understand the Vehicle Noise, Vibrations, Harshness, Comfort and Safety Systems.
4. To analyze the feasibility of alternate fuels / power source and emission control.

Course Content

Vehicle Structure, Comfort and Safety

Automobiles - Vehicle Construction - layouts, chassis, frame, body material and construction. Vehicle Aerodynamics - Flow phenomenon related to vehicles, drag, side force, lift force, rolling resistance, total road loads, performance optimization of car bodies. Introduction to vehicle dynamics. Ergonomics and anthropometry - Driver seat for comfort and safety, safety belts, Air bags, Use of energy absorbing system, Impact protection. Recent trends in automotive safety systems - Safety regulations and testing. Fundamentals of vehicle air-conditioning, cooling and heating system - automatic climate control. Noise, Vibrations and Harshness, Vehicle maintenance

Engine and Auxiliary Systems

SI and CI Engines – Principle of operation, components and materials. Air and Fuel systems - MPFI, GDI & CRDI, Turbochargers. Cooling and Lubrication systems. Typical performance, combustion and emission characteristics for automobile engines. Emission control and standards (Euro and BS). Recent Trends in Automobile Engine - Variable Timing Control (VTC), Variable-Valve Timing (VVT), Variable compression ratio (VCR) and Lift Electronic Control (VTEC), Homogenous Charge Compression Ignition (HCCI) Advanced Turbulent Flow Technology (ATFT), Dual Twin Spark –ignition(DTS-i), Stratified Charged Engine, Dual fuel engine. Alternate energy sources, electric and hybrid vehicles.

Transmission Systems

Transmission system – need and Construction of Clutch, Gear Box - Manual and Automatic - Over Drives – Transfer Box, Fluid flywheel, Torque convertors. Hydraulic control systems of automatic transmission. Continuously Variable Transmission (CVT). Propeller shaft - Hotchkiss drives, Torque tube drive, radius rods, Universal joints. Final drive - Differential - conventional and Non-slip types, differential locks. Rear axle construction - full floating, three quarter floating and semi-floating arrangements.

Steering, Brakes and Suspension Systems

Front axle - rigid and split axle, construction and materials. Front wheel geometry - camber, castor, kingpin inclination, toe-in and toe-out. Steering Geometry - Ackermann and Davis steering - steering linkages, steering gear box, power steering. Turning radius, instantaneous centre, wheel wobble and shimmy. Over steer and under steer. Hydraulic and Pneumatic Braking Systems - braking torque, materials, disc & drum brakes, brake actuating systems. Exhaust brakes, power and

power assisted brakes. Factors affecting brake performance, Antilock Braking System (ABS) and traction control. Suspension - types, factors influencing ride comfort, shock absorbers. Wheels and Tyres – construction and materials. Static and rolling properties of pneumatic tyres, tubeless tyres, aspect ratio, tyre wear and maintenance.

Automotive Electrical and Electronics

Introduction to automotive electrical systems - Automotive electricity generation, storage & distribution systems, wiring harness. Charging, starting & ignition System. Automotive lighting. Automotive Sensors & Actuators, Engine Management Control System (EMS). Vehicle Management System- vehicle tracking system, Collision avoidance, Radar warning system, Global Positioning Systems.

Reference Books:

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. Ganesan .V"Internal Combustion Egines" Third edition, Tata McGraw –hill, 2007.
6. J.B.Heywood, 'Fundamentals of Internal Combustion Engine', McGraw Hill Book Co, 1989.
7. P. L. Kohli, „Automotive Electrical Equipments", Tata McGraw Hill Pub. Co. Ltd.
8. Tom Denton, „Automobile Electrical & Electronic Systems", SAE International.
9. Tom Birch, "Automotive Heating and Air Conditioning" Pearson Education Inc., 2003.
10. William H Crouse and Donald L Anglin, "Automotive air conditioning", McGraw - Hill Inc., 1990
11. Automotive vehicle safety by George Peters and Barbara Peters, CRC Press, 2002.
12. Automotive Safety Handbook by Ulrich W. Seiffert and Lothar Wech, SAE International, 2007.

Course Outcomes

At the end of the course student will be able to:

1. Identify the automobile structure, various systems and components, Noise, Vibrations, Harshness, comfort and safety systems.
2. Differentiate between the principles of SI and CI engines and command over the recent development in the area of alternate fuels for automotive engines.
3. Understand the transmission system and principles of clutch, gear box, Propeller shaft, differential, axle, wheels, tyres, steering, brake and suspension system.
4. Appraise recent trends in Electrical and Electronics for Engine and Vehicle Management System.

Course Code	**:**	MEPC26
Course Title	**:**	DESIGN OF MECHANICAL DRIVES
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC12
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. To teach students how to formulate the design and manufacturing problem for simple systems and mechanical components
2. To teach students how to apply the general mechanical engineering sciences in analyses specific to the design of mechanical components and systems
3. To teach students in a laboratory setting how to generate concepts, conduct analyses to size components, construct and assemble a prototype of a system and test its function
4. To reinforce students team skills through team projects, including problem formulation, problem solutions and written and oral reporting of results
5. To reinforce students visualization and hands-on skills through project virtual prototyping and / or physical construction exercises

Course Content

Friction drives: design of wheels, pressure devices, calculation of force of pressure, metallic and non- metallic wheels for strength with parallel and intersecting shafts.

Belt and rope drives: calculation-selection, service life.

Gear drives: types-criteria of calculation- design load, load concentration factor, dynamic load factor, teeth surface strength, allowable contact stresses, design for beam strength, allowable bending stresses, seizure prevention- main geometrical dimensions- design of precision gears.

Chain drives: process of load transmission, forces acting on chain, proportions of sprockets, and chains.

Reduction and variable speed drives: types- gear box design.

Reference Books:

1. J Shigley, mechanical engineering design, 9th ed., McGraw Hill 2001.
2. Robert C Juvinall and Kurt M Marshek, Fundamentals of machine component design, 5th ed., John Wiley and sons Inc.,
3. Class materials.

Course Outcomes

At the end of the course student will
1. Recognize the need for friction drives and positive drives.
2. Apply BIS standards and catalogues in design and selection of belts and chain for requirement.
3. Select suitable drive combination based on requirement.
4. Explain failure modes in gears.
5. Establish suitability of a given drive elements whether to meet the requirement.

Course Code	**:**	MEPC29
Course Title	**:**	METROLOGY AND QUALITY CONTROL
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-

Course Type	:	PROGRAMME CORE

Course Learning Objectives

1. Describe the evolution of quality standards and metrology
2. Describe key points and timelines for the evolution of the quality system as we know it today
3. Define what a quality system is and why it is utilized, Identify and provide the uses for various quality tools such as check sheets, pareto charts, flowchart, cause and effect diagrams, histogram, scatter diagram and control charts

Course Content

Introduction to Metrology- Introduction to Metrology, Fundamental principles and definitions, measurement standards / primary and tertiary standards, distinction between precision and accuracy. Limits, fits 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/electronics 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 Equipments - Principles of measurement using Tool Maker's microscope profile projector & 3D coordinate measuring machine

Quality Control - Introduction, definition and concept of quality & quality control, set up policy and objectives of quality control, quality of design and quality of conformance, compromise between quality & cost, quality cost and planning for quality

Sqc and Sqc Tools - Importance statistical methods in QC, measurement of statistical control variables and attributes, pie charts, bar charts/ histograms, scatter diagrams, pareto chart, GANT charts, control charts, X chart, X bar charts, R charts, P charts, np charts their preparation, analysis and applications. Elementary treatment on modern SQC tools. Sampling inspection and basic concepts, OC curves, consumer & producer risk, single & double sampling plans and use of sampling tables.

Reference Books:

1. Gupta, I.C., Engineering Metrology, Dhanpat Rai & Sons, 2004.
2. Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004.
3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.

Course Outcomes

At the end of the course student will
1. Demonstrate different measurement techniques.
2. Reproduce the fundamental knowledge on metrology techniques.

3. Apply statistical process control and acceptance sampling procedures in a manufacturing environment to improve quality of processes / products.
4. Identify suitable metrological methods for measuring the components.
5. Explain the acceptance test for machines.
6. Outline the working of various optical measuring instruments.

Course Code	**:**	MEPC21
Course Title	**:**	TURBOMACHINES
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC18
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

The course is designed to introduce, through the law of Fluid Mechanics and Thermodynamics, the means by which the energy transfer is achieved in major types of turbomachines together with the differing behavior of individual types in operation. The course objectives are

1. To introduce basic principles and equations governing the steady and unsteady compressible fluid flow associated with the turbomachineries.

2. To teach the design aspects of the turbomachinery parts and the methods to analyze the flow behavior, which depends on the geometric configuration of the turbomachines, as well as the machine produces or absorbs work will be introduced.

Course Content

Fundamentals: Classification, Applications of turbomachines, Performance parameters, Specific speed, Basic laws and equations, Velocity triangles.

Hydraulic turbines: Specific applications, types, construction, working and performance of various types of hydraulic turbines (Pelton, Francis, and Kaplan turbines), Cavitation in turbines and water hammer effects, Draft tube: Types, applications and performance analysis.

Centrifugal pumps: Theory, types, components, and working characteristics, Cavitation, NPSH, Priming, Axial flow pumps, Practical problems and remedies.

Thermal turbines: Steam turbine basic cycles, impulse and reaction turbines, Multistage turbines, Governing systems, Effects of reheating and regeneration, Application of Mollier diagram, Gas turbine basic cycle, Application of intercooling, reheating and regeneration, Introduction to wind turbines, Power and efficiency calculations.

Air compressors: Radial and axial compressors, Construction and performance analysis, Surging and stalling, Slip. Introduction to experimentations: Cascade analysis, Fluid flow measurements, Wind-tunnel techniques, Loss mechanisms in turbomachines.

Reference Books:

1. Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbomachines, 5th ed., Butterworth-Heinemann, 2005.
2. Sayers, A.T., Hydraulic and Compressible Flow Turbomachines, CBLS, 2003.
3. Ganesan, V., Gas Turbines, 2nd ed., Tata McGraw-Hill, 2003.
4. Lakshminarayana, B., Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley-Interscience, 1995.
5. D. S. Kumar, Fluid Mechanics and Fluid Power Engineering, Pub.: S. K. Kataria & Sons, New Delhi
6. Lakshminarayana, B., Fluid Dynamics and Heat Transfer of Turbomachinery, Pub.: Wiley-Interscience, 1995.
7. Yunus A. Cengel, John M. Cimbala, Fluid Mechanics – Fundamentals and Applications, Pub.: Tata McGraw Hill

Course Outcomes

At the end of the course student will
The terminal objectives of the course is that, on successful completion of teaching-learning and evaluation activities, the students would be able to identify and analyze the various types of turbomachines and they can demonstrate a basic understanding of laws of compressible flow in association with the turbomachinery. In addition, they are equipped with the technical knowledge to design major components and do maintain turbomachines.

Course Code	**:**	MEPC28
Course Title	**:**	POWER PLANT ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC21
Course Type	**:**	**PROGRAMME CORE**

Course Learning Objectives

1. Describe sources of energy and types of power plants
2. Analyze different types of steam cycles and estimate efficiencies in a steam power plant
3. Describe basic working principles of gas turbine and diesel engine power plants. Define the performance characteristics of such power plants
4. List the principal components and types of nuclear reactors.

Course Content

Thermal plant layout – working – Auxiliaries - Rankine cycle – improvement and limitations - Boiler types, circulation systems – Efficiency calculation - supercritical boilers – Fluidised 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 wind mills – Operation & recent developments. Power plant economics.

Reference Books:

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, 2nd Ed, 1984.
3. Nag. P.K., Power Plant Engineering, Tata McGraw-Hill, 4th Ed, 2014.

Course Outcomes

At the end of the course student will
1. Summarize the layout and components in a power plant.
2. Enumerate and classify the types of power plants available.
3. Recognize the steam cycles on pressure-volume and temperature diagram.
4. Outline the scenario of entire business of power plants along with performance parameters, load curves and tariff calculations.
5. Extend their knowledge to power plant economics and environmental hazards

III.ELECTIVES

a. PROGRAMME ELECTIVE (PE)

Course Code	**:**	MEPE10
Course Title	**:**	COMPRESSIBLE FLOW AND JET PROPULSION
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC18
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

This course introduces the concepts of the primary differences between an incompressible flow and compressible flow. It draws the connection between compressible flow and speed of sound, Mach number and thermodynamics. The physical concept of shocks, and compressible fluid flows with effects of friction and heat transfer and the resulting changes in the thermodynamic properties of a fluid form a major part of this course. The course concentrates primarily on the understanding of the physical concepts of compressible flow and keeps reference to various numerical methods for solving the governing equations to a minimum. In addition, concepts of fluid flows in nozzles, diffusers and inlets of aircraft engines and the forces, moments, and loss generation resulting from compressible fluid flow interactions with aerodynamic shapes will be introduced.

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 flow through variable area passage ducts - Flow through nozzles and diffusers, chocked flow, critical pressure ratio, application of equation of critical pressure ratio, variation of Mach number with reference to cross sectional area.

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 - types of aircraft engines, propulsion cycle, power and efficiency calculations, turbojet, turbofan, and turboprop engines, basic concepts of rocket propulsion, engine types, construction and fuels

References books:

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

Course Outcomes:

At the end of the course student will
The terminal objectives of the course is that, on successful completion of teaching-learning and evaluation activities, a student would be able to identify, appreciate and analyze the compressible fluid flow problems by applying the fundamental technologies of fluid mechanics in constant area & converging / diverging ducts, fluid flow with shocks, heat transfer and frictional effects.
In addition, they will be in a position to understand and discuss the mechanism of jet propulsion and engines of aircrafts and rockets.

Course Code	**:**	MEPE11
Course Title	**:**	COMPUTATIONAL FLUID DYNAMICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC18
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To introduce numerical modeling and its role in the field of heat transfer and fluid flow.
2. To enable the students to understand the various discretization methods and solving methodologies.

3. To create confidence to solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers

Course Learning Objectives

1. To introduce numerical modeling and its role in the field of heat transfer and fluid flow.
2. To enable the students to understand the various discretization methods and solving methodologies.
3. To create confidence 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 Unsteady State Problems: 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: FVM for 2-D unsteady state diffusion 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, 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.

Reference Books:

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.

Course Outcomes

At the end of the course student will
1. Express numerical modeling and its role in the field of fluid flow and heat transfer.
2. Estimate the various errors and approximations associated with numerical techniques
3. Apply the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems.
4. Interpret the knowledge, capability of analyzing and solving any concept or problem associated with heat energy dynamics and utilization.
5. Illustrate the working concepts of thermal engineering devices.

Course Code	**:**	MEPE12
Course Title	**:**	ADVANCED IC ENGINES
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. Learn to classify different types of internal combustion engines and their applications.
2. Apply principles of thermodynamics, fluid mechanics, and heat transfer to the design and analysis of engines and engine components.
3. Become aware of the relevance of environmental and social issues on the design process of internal combustion engines.
4. Develop mathematical methods for designing components and systems
5. Apply numerical methods to perform design calculations.
6. Advance proficiency in professional communications and interactions.

Course Content

Combustion process in SI and CI engines, Combustion chambers and abnormal combustion.

Composition and effect of Fossil and Alternative Fuels in IC Engine.

IC Engine Modelling – Zero dimensional, Two zone and Multi zone modelling

Instrumentation to study the combustion process in engines such as Particle image velocimetry, Holographic PIV, Spray visualization, Phase Doppler interferometry for spray characterization.

Pollutant formation in SI and CI engines and Control measures such as DOC, DPF, SCR, and LNT

Reference Books:

1. Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
2. Fundamentals of internal combustion engines: Gill, Smith and Ziurys, Oxford and IBH.
3. The Internal combustion Engine in theory and practice: C F Taylor, MIT Press, Cambridge.

4. Internal Combustion Engines and Air Pollution: E F Obert, Intext Educational Publishers, NY.
5. Alternative Fuels Guidebook, Properties, Storage, Dispensing, and Vehicle Facility Modifications, Richard L. Bechtold, SAE Publications 1997.
6. Emission from Combustion engines and their control, Patterson D J and Henein N A: Ann Arbor science publishers.
7. Advanced Engine Technology: Heinz Heisler ISBN 0340568224, SAE Publications.
8. Engines: An Introduction, John L Lumley.

Course Outcomes

At the end of the course student will

1. Understand the combustion phenomena in SI and CI engines.
2. Study the characteristics of fossil and alternative fuels and their effect on the performance of IC engines.
3. Explain the recent technologies to tradeoff engine performance and emission characterization.
4. Explain the advanced imaging techniques to study the combustion and spray characteristics of the fuel.
5. Identify the exhaust pollutants and measurement techniques.

Course Code	**:**	MEPE13
Course Title	**:**	COMBUSTION ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. This course starts with a review of chemical thermodynamics, statistical mechanics, equilibrium chemistry, chemical kinetics, and conservation equations.
2. Then the following subjects are covered: chemical and dynamic structure of laminar premixed, diffusion, and partially premixed flames; turbulent premixed combustion; turbulent diffusive combustion in one and two-phase flows;
3. Aerodynamics and stabilization of flames; ignition, extinction and combustion instabilities; non-intrusive combustion diagnostics and flame spectroscopy.

Course Content

Combustion of fuels - Combustion equations and air-fuel ratio calculations.

Thermodynamics of combustion - Thermochemistry - Kinetics of combustion.

Laminar and turbulent flames - Quenching, flammability, ignition and flame stabilization. Combustion in SI and CI engines.

Emission and control methods.

Reference Books:

1. Turns, S.R., An Introduction to Combustion, 2nd ed., McGraw-Hill, 2000.

2. Glassman, I**.,** Combustion, 3rd ed., Academic Press, 1996.
3. Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988.
4. Mukunda, H.S., Understanding Combustion, Macmillan, 1992.

Course Outcomes

At the end of the course student will

1. Formulate combustion equations to determine A/F, adiabatic flame temperature and pollutant concentration.
2. Relate the thermo chemistry and kinetics of combustion to evolve mathematical models for combustion.
3. Identify factors responsible for laminar and turbulent flame propagation.
4. Apply the different principles of flame stabilization and ignition to design combustor.
5. Summarize emission associated with combustion and identify their control techniques.

Course Code	**:**	MEPE14
Course Title	**:**	BIOFUELS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To characterize different biomass feedstock's based on its constituents and properties & understand the analytical techniques to characterize biomass.
2. To Understand and evaluate various biomass pre-treatment and processing techniques in terms of their applicability for different biomass types.
3. To provide students with the basic principles of biofuels and bioenergy systems design.
4. To identify biofuels and bioenergy sources; describe biofuels and bioenergy technologies,
5. To distinguish applications and efficiency; analyze biofuels and bioenergy manufacturing, distribution and integration issues.

Course Content

Importance of bioenergy and biofuels in solving energy crisis and global warming. Introduction to various biomass types – constituents, characterization. Biogas & bio-electricity, Bio-heat; Clean sustainable bioenergy, bio-electricity and biogas production from Dairy manure and Food Waste streams.

Biomass pre-treatment: Acid/alkali treatment, steam explosion, ammonia fibre expansion, enzymatic, ball milling, other non-conventional techniques, choice of pre-treatment based on biomass types. Pellets made from wood or grass biomass are commercially available at stores for heating homes, schools, businesses.

Seed-based biodiesel, bioethanol, conversion of waste oil to biodiesel, advanced biofuels including algae-biofuel, microbial biofuel, Conversion of waste vegetable oil into biodiesel, and advanced innovations in enzymatic conversion of non-food feed-stocks. Fuel properties, engine applications.

Biomass conversion technologies for biofuel. Thermochemical processes: Combustion, gasification, pyrolysis, hydrothermal liquefaction, hydropyrolysis, torrefaction, choice of thermal process based on biomass type and product requirement.

Biofuels/energy related environmental, economics, & social issues. The source, processing, and social impacts of biofuel utilization

Reference Books:

1. Filemon A. Uriarte Jr., Biofuels from plant oils, National Academy of Science and Technology, 2010.
2. Anju Dahiya, Bioenergy: Biomass to Biofuels, Eslevier, 2015
3. Sunggyu Lee and Y.T. Shah, Biofuels and Bio-energy Processes and Technology, CRC Press, Taylor and Francis Group, 2013.
4. Pandey, A., Larroche, C., Ricke, S.C., Dussap, C.-G., Gnansounou, E., Biofuels: Alternative feedstocks and conversion processes, Academic Press, U.S.A., 2011.
5. Brown, R.C. (Ed.) Thermochemical processing of biomass into fuels, chemicals and power, Wiley, 2011.
6. Clark, J., Deswarte, F. (Ed.) Introduction to chemicals from biomass, John Wiley and Sons, U.K., 2008.
7. Understanding clean energy and fuels from biomass, H. S. Mukunda, 2011

Course Outcomes

At the end of the course student will be able to

1. Describe the nature and principle of different biomass energy extraction systems and know how to choose the suitable biomass fuels for different bio-energy applications;
2. Address the desirable features of these biomass energy sources and their advantages over traditional fuels such as coal and oil
3. Identify their limited scope in terms of suitable sites, dependence on the elements, capital costs, and cost effectiveness compared with traditional sources

Course Code	**:**	MEPE15
Course Title	**:**	REFRIGERATION AND AIR CONDITIONING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To understand the principles of refrigeration and air conditioning.
2. To calculate the cooling load for different applications.
3. To select the right equipment for a particular application.
4. To design and implement refrigeration and air conditioning systems using standards.
5. Energy Conservation and Management.

Course Content

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

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.

Reference Books:

1. Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2000
2. Dossat R.D., Principle of Refrigeration, 4th ed., Prentice-Hall, 1997.
3. Manohar Prasad, Refrigeration and Air Conditioning, New Age International, 2004.

Course Outcomes

At the end of the course student will
1. Illustrate the basic concepts of refrigeration system.
2. Analyze the vapour compression cycle and interpret the usage of refrigerants.
3. Explain the components of vapour compression system.
4. Demonstrate the use of psychrometry in analyzing refrigeration systems.

Course Code	**:**	MEPE16
Course Title	**:**	FUNDAMENTALS OF HVAC SYSTEMS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To learn climate variation and its effects on the building heat load.
2. To learn building material characteristics and their influence on building heating / cooling load for all weather conditions.
3. To study various conversation techniques related to build environment and codes for the same.

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.

Reference Books:

1. Hand book 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

At the end of the course student will

1. Estimate heating loads, space heat gains and space cooling loads using accepted engineering methods.
2. Determine the coil loads for cooling and heating systems.
3. Select equipment and design systems to provide comfort conditions within the building.

Course Code	**:**	MEPE18
Course Title	**:**	NANOTECHNOLOGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC20
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. Understand how basic nanosystems work

2. Use physical reasoning to develop simple nanoscale models to interpret the behaviour of such physical system
3. Understand the major issues in producing a sustainable nanotech industry

Course Content

Introduction to the course, Historical perspective of micro and nano manufacturing technology, Advantages and applications of nanotechnology

Materials overview, atomic structure, bonding, polymers, electrical characteristics, periodic table, crystal structures and defects, physical chemistry of solid surfaces, Introduction to Si-based materials, Ge-based materials, nanomaterials preparation.

Overview of Nano Fabrication Methods: Top-down and bottom-up approaches, lithography, deposition, CVD - Basics related to nucleation and crystal growth mechanism, PVD, ALD, etching, and material modification methods, processes and equipment, Characterization Tools, Optical microscopy, Profilometry, Ellipsometry, Spectrophotometer, Scanning Electron Microscope, AFM, FFM.

Zero dimensional Nano structures (Nano Particles) - Fabrication procedures, sol-gel processing, applications, properties and applications of Nano Particles, One dimensional Nano structures - Nano wires and nano rods, fabrication methods, Properties and applications of Nano Wires, nano fluids, Two dimensional nano structures.

Top down fabrication procedures, Lithography, Pattern transfer methods, Wet Etching and Dry etching, Nano material characterization methods, Application of nano materials, Carbon Nano Tubes, Quantum dots, thermal insulation, Organic compounds and bio-applications of nano materials.

Reference Books:

1. Jeremy J. Ramsden, Nanotechnology An Introduction, Elsevier, 2011.
2. Amretashis Sengupta, Chandan Kumar Sarkar, Introduction to Nano: Basics to Nanoscience and Nanotechnology (Engineering Materials), Springer, 2015.
3. William Illsey Atkinson, Nanotechnology, Amacom, 2010.

Course Outcomes

At the end of the course student will
1. Demonstrate a working knowledge of nanotechnology principles and industry applications.
2. Explain the nanoscale paradigm in terms of properties at the nanoscale dimension.

Course Code	**:**	MEPE19
Course Title	**:**	VEHICLE DYNAMICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC25
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. In-depth understanding of specialist bodies of knowledge within the engineering discipline
2. Application of established engineering methods to complex engineering problem solving
3. Fluent application of engineering techniques, tools and resources

Course Content

Multi Degree of Freedom Systems: Closed coupled system, Eigen valve problems, Far coupled systems-Orthogonality of mode shapes-Modal analysis, Forced vibration by matrix inversion. Suspension and Tyres: Requirements. Spring mass frequency.

Wheel hop, wheel wobble, wheel shimmy. Choice of suspension spring rate. Calculation of effective spring rate. Vehicle suspension in fore and apt directions. Ride characteristics of tyres, behaviour while cornering, power consumed by tyre, effect of driving and braking torque-Gough'styre characteristics.

Vehicle Handling: Oversteer, under steer, steady state concerning. Effect of braking, driving torques on steering. Effect of camber, transient effects in concerning. Directional Stability of vehicles. Stability of Vehicles: Load distribution.

Calculation of tractive effort and reactions for different drives-Stability of a vehicle on a slope, on a curve and a banked road.

Numerical Methods: Approximate methods for fundamental frequency, Dunker-Ley's lower bound, Rayleigh's upper bound-Holzer method for close-coupled systems and branched systems.

Reference Books:

1. Gillespie. T.D., Fundamentals of vehicle dynamics society of Automotive Engineers, Ic USA 1992.
2. Heldt. P.M. Automotive Chassis, Chilton co., New York, 1992
3. Ellis.J.R., Vehicle Dynamics, Business Books Ltd., London, 1991.
4. Giles. J.G. Steering, Suspension and Tyres, IIIifee Books Ltd, London, 1988.
5. Giri. N.K. Automobile Mechanics, Khanna Publishers. New Delhi, 1986.
6. Rao. J.S. & Gupta. K., Theory and Practice of Mechanical Vibrations, Wiley Eastern Ltd., New Delhi, 1999.

Course Outcomes

At the end of the course student will
1. Develop physical and mathematical models to predict the dynamic response of vehicles;
2. Apply vehicle design performance criteria and how to use the criteria to evaluate vehicle dynamic response;
3. Modify a model of a vehicle to enable it to meet design performance criteria;

Course Code	**:**	MEPE21
Course Title	**:**	DYNAMICS OF MACHINERY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC23

Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To understand the force-motion relationship in components subjected to External Forces
2. To analyse the force-motion characteristics of standard mechanisms
3. To study the undesirable effects of unbalances resulting from prescribed motions in mechanism.

Course Content

Single degree of freedom systems - Periodic excitations - Impulse response - Virtual work.

Forced vibrations.

Two degree of freedom systems - coupled vibrations.

Vibration of continuous systems.

Wave and Euler equations - Vibration of plates.

Reference Books:

1. Rao, J.S. and Gupta, K., Introductory Course on Theory and Practice of Mechanical Vibration, New Age International Pvt. Ltd., 2004.
2. Thomson, W.T., Theory of Vibration with Applications, CBS Publishers, New Delhi, 1990.

Course Outcomes

At the end of the course student will
1. State the single degree of freedom systems.
2. Sketch the impulse response for a periodic excited virtual work.
3. Examine the concept of forced vibration.
4. Extend the concept to two degree of freedom systems.
5. Manipulate the vibration of continuous systems.
6. Solve problems using wave and Euler equations.

Course Code	**:**	MEPE22
Course Title	**:**	MEMS DEVICES – DESIGN AND FABRICATION
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC13
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To think in an unified way about interdisciplinary Microsystems
2. Understand the operation of a wide range of sensors and actuators appropriate for microscale systems encompassing different energy domains represent microsystems as generalized networks.

3. To design, analysis and simulation master 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 devices and technologies, and an introduction to design and modeling.

Standard microelectronic fabrication technologies; bulk micromachining, surface micromachining, bonding technologies, related fabrication methods, and creating process flows.

Mechanical, thermal, electrical, magnetic, optical, and chemical properties of materials.

Introduction to lumped modeling of systems and transducers; an overview of system dynamics.

MEMS and NEMS examples, energy methods, the thermal energy domain; modeling dissipative processes,

Fluids and Transport.

Reference Books:

1. Tai – Ran Hsu, "MEMS& Microsystems Design and Manufacturing", Tata McGraw-hill Edition, 2006
2. Mohamed Gad-el-Hak, "MEMS: Design and Fabrication (Mechanical Engineering)", CRC; 1st edition, 2005.
3. Marc J. Madou, "Fundamentals of Microfabrication, the science of Miniaturization", CRC Press Second Edition, 2002.
4. Sami Franssila, "Introduction to Microfabrication", John Wiley; 1 edition, 2004.
5. John A. Pelesko, David H. Bernstein, "Modeling MEMS and NEMS", CRC; 1 edition, 2002.
6. Micro and smart systems, Anantha Suresh, Tata McGraw-hill edition, 2013

Course Outcomes

At the end of the course student will
1. Illustrate on the design and modeling of MEMS components.
2. Explain the various MEMS fabrication technologies.
3. Describe the mechanical, thermal, electrical, magnetic and chemical properties of materials.
4. Discuss the lumped modeling of systems and transducers.
5. Interpret the micro system dynamic.

Course Code	**:**	MEPE24
Course Title	**:**	OIL HYDRAULICS AND PNEUMATICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC18
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. The cognitive objective of this course is for each student to comprehend foundational knowledge needed to perform stated entry-level industry competencies.
2. The performance objective of this course is for each student to apply foundational knowledge to hydraulic and pneumatic problems and exercises encountered in class.

Course Content

Basic concepts of fluid power system design - Hydraulic oils and fluid properties – Seals and Seal materials - Filters and Filtration.

Hydraulic pumps, cylinders, and motors - Construction, sizing, and selection.

Control valves; pressure, flow, and direction - Servo-valves.

Basic hydraulic circuits, hydrostatic transmission - Cartridge valve circuits.

Control of hydraulic circuits - Electrical, electronics, and PLC - Pneumatic components and basic circuits.

Reference Books:

1. Esposito. A., Fluid Power with Applications, 5th ed., Pearson Education, 2003.
2. Industrial Hydraulics, Vickers - Sperry Manual, 2002.

Course Outcomes

1. Recall various fluid properties and identify the appropriate fluid power system for particular application.
2. Recognize the suitable pump and actuators for particular application.
3. Select various control valves such as pressure control, flow control, direction control valves and use them in hydraulic and pneumatic circuit development.
4. Analyze the hydraulic and pneumatic circuit for energy efficiency.
5. Select the appropriate control system like electrical, electronics, and PLC to control the fluid power system.
6. Trouble-shoot and identify maintenance problems associated with fluid power system.

Course Code	**:**	MEPE25
Course Title	**:**	INDUSTRIAL ROBOTICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC13
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To introduce the basic concepts, parts of robots and types of robots

2. To make the students familiar with the various drive systems for robot, sensors and their applications in robots, programming of robots
3. To discuss about the various applications of robots, justification, implementation and safety of robot.

Course Content

Robot – Definition – Robot Anatomy – Co-ordinate Systems, Work Envelope, types and classification – Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load –

Robot Parts and Functions – Need for Robots – Different Applications, Principles and problems in robot design and control

Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications and Comparison of

Drives End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations

Requirements of a sensor, Principles and Applications of the following types of sensors – Position of sensors (Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, Pneumatic Position Sensors), Range Sensors (Triangulation Principle, Structured, Lighting Approach, Time of Flight Range Finders, Laser Range Meters), Proximity Sensors (Inductive, Hall Effect, Capacitive, Ultrasonic and Optical Proximity Sensors), Touch Sensors, (Binary Sensors, Analog Sensors), Wrist Sensors, Compliance Sensors, Slip Sensors. Camera, Frame Grabber, Sensing and Digitizing Image Data – Signal Conversion, Image Storage, Lighting Techniques. Image Processing and Analysis – Data Reduction: Edge detection, Segmentation Feature Extraction and Object Recognition - Algorithms. Applications – Inspection, Identification, Visual Serving and Navigation.

Forward Kinematics, Inverse Kinematics and Differences; Forward Kinematics and Reverse Kinematics of Manipulators with Two, Three Degrees of Freedom (In 2 Dimensional), Four Degrees of Freedom (In 3 Dimensional) – Deviations and Problems. Teach Pendant

Programming, Lead through programming, Robot programming Languages – VAL Programming – Motion Commands, Sensor Commands, End effecter commands, and Simple programs

RGV, AGV; Implementation of Robots in Industries – Various Steps; Safety Considerations for Robot Operations; Economic Analysis of Robots – Pay back Method, EUAC Method, Rate of Return Method.

Reference Books:

1. Mair, G.M., Industrial Robotics, Prentice-Hall, 1988.
2. Considine, D.M. and Considine, G.D., Standard Hand Book of industrial Automation, Chapman and Hall, 1986.
3. Groover, M.P., Weiss, M., Nagel, R.N., and Odrey, N.G., Industrial Robotics, Technology, Programming, and Applications, McGraw-Hill, 1995.

Course Outcomes

At the end of the course student will

1. Classify and characterize the robots based on the configuration and work volume.
2. Explain and solve the problems related to robot design and control.
3. Illustrate the working of the transmission system in a robot.
4. Discuss the concept of vision system and image processing.
5. Write programs for automatic functioning of a robot.
6. Design a working model of a robot using the concepts and principles learnt.

Course Code	**:**	MEPE26
Course Title	**:**	MECHATRONICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC13
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. Apply mechanical engineering and electrical engineering knowledge and skills to problems and challenges in the areas of mechatronic engineering.
2. Integrate and use systems or devices incorporating modern microelectronics, information technologies and modern engineering tools for product design, development and manufacturing.
3. Engage in lifelong learning in their profession and practice professional and ethical responsibility.

Course Content

Introduction to mechatronics- Historical perspective- Key elements of a mechatronic system- Examples of mechatronic systems.
Sensors and Transducers – Signal conditioning and Data acquisition systems.

Actuation systems– Pneumatic and Hydraulic system, mechanical and electrical actuation systems.
Smart materials and Systems – Piezoelectric actuators– Shape memory alloy (SMA) actuators, Magneto rheological and Electro rheological Fluids and its applications; Dampers, Clutch, Valves etc..
System models – Engineering systems- Rotational translational systems – Electromechanical systems – Hydraulic mechanical systems – Dynamic responses of systems – Frequency response- Closed loop controllers.
Introduction to microcontrollers and microprocessors– Interfacing microcontrollers with sensors and actuators – Introduction to Programmable logic controllers (PLC) – Case Studies of mechatronic systems.

Text Books:

1. Godfrey Onwubolu, Mechatronics – Principles and Applications, Butterworth – Heinemann, 2005
2. David G. Alciatore, Michael B. Histand, David Alciatore, Introduction to Mechatronics and Measurement Sytems, McGraw Hill; second edition, 2002
3. W. Bolton, Mechatronics- Electronic control systems in Mechanical and Electrical Engineering, second edition, Pearson Education, 2001.

Reference Books:

1. Robert H Bishop, The Mechatronics Handbook CRC Press, 2002

Course Outcomes

At the end of the course student will
1. To employ the basic mathematical skills needed to solve routine engineering problems.
2. To demonstrate knowledge of electrical circuits and logic design.
3. To implement engineering solutions and techniques to solve design problems.
4. To design mechatronic components and systems.
5. To apply spreadsheets, computer-based modeling and other computer-based methods to solve mechatronic problems.
6. To communicate through writing with others in the field of mechatronics.

Course Code	**:**	MEPE27
Course Title	**:**	INDUSTRIAL TRIBOLOGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC20
Course Type	**:**	**PROGRAMME ELECTIVE**

Course Learning Objectives

1. To impart knowledge on friction, wear and lubrication
2. To acquire knowledge on surface coatings and 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

Reference Books:

1. Hulling , J. (Editor) --"Principles of Tribology", MacMillan, 1984.
2. Williams J.A . "Engineering Tribology" ,Oxford Univ. Press,1994.
3. Neale M.J , "Tribology Hand Book ", Butterworth Heinemann, 1995.
4. I.M. Hutchings, “Tribology: Friction and Wear of Engineering Materials”, Elsevier Limited, 1992.
5. G. W. Stachowiak, A. W. Batchelor, “Engineering Tribology”, Elsevier Limited, 2005.
6. K.C. Ludema, “Friction, wear, lubrication: A text book in tribology”, CRC Press, 1996.
7. Bharat Bhushan, “Nanotribology and Nanomechanics: An Introduction”, Springer, 2008.

Course outcome

At the end of the course student will
1. Apply the knowledge of tribology in industries
2. Identify the types of wear
3. Know the working of surface measuring instruments

Course Code	**:**	MEPE29
Course Title	**:**	RENEWABLE ENERGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. To enable the students to understand the principle of working and the components of different non-conventional sources of energy and their utilization.
2. To get an exposure to the wind energy, Biomass, geothermal energy, tidal energy, fuel cells and energy conversion technologies.

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 –- Carbonisation – 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.

Reference Books

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. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K., 2012.
4. S.P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2009.
5. G.N. Tiwari, "Solar Energy – Fundamentals Design, Modelling and applications", Alpha Science Intl Ltd, 2015.
6. B.H. Khan, "Non-Conventional Energy Resources", The McGraw Hill companies, 2009

Course Outcomes

At the end of the course student will

1. To estimate solar radiation and formulate heat transfer equations and analyze of modern energy conversion technologies
2. To describe various renewable energy resources and techniques to utilize them effectively.
3. Compute wind energy potential and predict the performance of wind turbines.
4. Describe and analyze photovoltaic systems.
5. Explain the energy harvesting methods from various energy sources.
6. Distinguish the various form of energies such as magneto hydrodynamic, thermionic and fuel cell.

b. OPEN ELECTIVE

Course Code	**:**	MEOE11
Course Title	**:**	FINITE ELEMENT METHOD
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. The objective of the course is to apprise the students about the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems in solid mechanics.

2. Different application areas will be dealt with after introducing the basic aspects of the method.
3. The analysis methodologies for 1-D, 2-D and 3-D problems with the advantages and disadvantages clearly spelt out.
4. It is expected that once the students are exposed to the course, they will be in a position to develop computer codes for any physical problem using Finite Element technique

Course Content

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

One-dimensional finite element analysis; bar element, beam element, frame element - Heat transfer problems.

Two-dimensional finite element analysis; types of elements, shape functions, natural coordinate systems.

Applications to structural mechanics - Numerical integration - Solution of finite element equations.

Fluid flow problems - Dynamic problems.

Reference Books:

1. Seshu, P., Textbook of Finite Element Analysis, Prentice-Hall, India, 2003.
2. Segerlind, L.J., Applied Finite Element Analysis, John Wiley, 1987.

Course Outcomes

At the end of the course student will
1. Illustrate the basic concepts of finite element systems through spring systems and by solving problems.
2. Interpret one-dimensional and two-dimensional finite element analysis with examples.
3. Apply finite element methods to real world problems and obtain solutions.

Course Code	**:**	MEOE12
Course Title	**:**	COMPOSITE MATERIALS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

To impart knowledge on the structure, properties, treatment, testing and applications of metals and non-metallic materials so as to identify and select suitable materials for various engineering applications.

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.

Manufacture of glass, boron and carbon fibers-Manufacture of FRP components- Open mould and closed mould processes. Properties and functions of resins.

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

Reference Books:

1. R.M. Jones, "Mechanics of Composite Materials", 2nd Edition, Taylor & Francis, 1999
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. G.Lubin, "Hand Book on Fibre glass and advanced plastic composites", Van Nostrand Co., New York, 1989.
5. B.D. Agarwal and L.J. Broutman, "Analysis and Performance of fiber composites", John-Wiley and Sons, 1990.

Course Outcomes

At the end of the course student will

1. Given a type of material, be able to qualitatively describe the bonding scheme and its general physical properties, as well as possible applications.
2. Given a type of bond, be able to describe its physical origin, as well as strength. Be able to qualitatively derive a material's Young's modulus from a potential energy curve.

Course Code	**:**	MEOE13
Course Title	**:**	ADVANCES IN WELDING TECHNOLOGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

To study the different types of welding process and its application in various fields

Course Content

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

TIG / A-TIG Welding, gas metal arc welding**,** Submerged arc welding, Friction welding, Explosive welding, Plasma arc welding

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

Friction welding process - effects of speed and pressure –Types- Explosive welding –Process Parameters-Plasma arc welding

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

Reference Books:

1. Parmar,R.S., “Welding Processes and Technology”, Khanna Publishers, 1997.
2. Heine,R.W., Loper,C.R. and Rosenthal,P.C., "Principles of Metal casting", Tata McGraw- Hill, 1994.
3. Lancaster J.F, ‘The Physics of Welding’, Pergamon Press, 1984
4. American Society of Welding, "Hand book of Welding", Vol.I to V.
5. Jain,P.L., “Principles of Foundry Technology”, Tata McGraw Hill, 2003.
6. Weman,K., “welding processes hand book”, CRC Press,2003.
7. Nadkarni S.V., ‘Modern Arc Welding Technology’, Oxford and IBH Publishing, 1996

Course Outcomes

At the end of the course student will be able to get the knowledge about newly developed welding process and its parameters

Course Code	**:**	MEOE14
Course Title	**:**	INDUSTRIAL SAFETY ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. To imbibe knowledge on safety management functions and its techniques.
2. To imbibe knowledge on accident reporting & investigation procedure.
3. To imbibe knowledge on safety education & training evaluation of safety performance in an organization.
4. To imbibe knowledge on workplace hazards & its control

Course Content

Evolution of modern safety concept- Safety management functions - safety policy - Safety Organization - Safety Committee - budgeting for safety - Behaviour based Safety.

Safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign

Concept of an accident, reportable and non reportable accidents, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis – records for accidents, departmental accident reports, documentation of accidents – unsafe act and condition – domino sequence – supervisory role – cost of accident.

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

Toxicity- TLV- Types of Chemical Hazards-Occupational diseases caused by dust, fumes, gases, smoke and solvent hazards- control measures

Fire triangle- Types of fire - first aid fire fighting equipment – flammability limit- LPG safety - Hazard identification and Risk Analysis.

Overview of factories act 1948 – ISO-45001

Reference Books:

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

Course Outcomes

At the end of the course student will

1. Apply principles of safety management, its functions and technique in any organization,
2. Classify and categorize the factors contributing to accident,
3. Formulate accident investigation program in an organization, practice and develop accident reporting system within an organization and calculate accident indices for monitor ing safety performances,
4. Apply material handling and machine guarding principles in industrial applications.
5. Realize chemical hazards, toxicity, fire and explosion in the work place and involve to take various control measures to prevent hazards.

Course Code	**:**	MEOE15
Course Title	**:**	OPTIMIZATION IN ENGINEERING DESIGN
Number of Credits	**:**	3
Prerequisites (Course code)	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. Earn how MSDO can support the product development process of complex, multidisciplinary engineered systems
2. Learn how to rationalize and quantify a system architecture or product design problem by selecting appropriate objective functions, design parameters and constraints
3. Subdivide a complex system into smaller disciplinary models, manage their interfaces and reintegrate them into an overall system model

Course Content

Introduction - Optimization techniques.

Single and multi-variable optimization.

Constrained optimization.

Specialized algorithms - Integer, geometric.

Nontraditional algorithms.

Reference Books:

1. Deb, Kalyanmoy, Optimization for Engineering Design, Prentice - Hall, 1995.
2. Rao. S.S., Optimization Theory and Applications, Wiley Eastern Ltd., 1998.

Course Outcomes

At the end of the course student will

1 Enumerate the necessity of optimization in engineering design.
2 Identify the various optimization techniques pertaining to design oriented problems.
3 Solve problems with single and multi – variable.
4 Formulate constrained optimization problems.
5 Distinguish between integer and geometric specialized algorithm
6 Apply non-traditional algorithms for optimization of typical problems requiring their application.

Course Code	**:**	MEOE16
Course Title	**:**	CRYOGENIC ENGINEERING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. To builds a solid foundation in the fundamentals of cryogenics
2. To encourage a "hand's – on" approach to solving cryogenic problems
3. To provide update cryogenic information

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.

Binary Mixtures, T-C and H-C Diagrams , Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method , Adsorption Systems for purification.

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.

Reference Books:

1. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.
2. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1988.
3. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York, 1989.
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

1. Introduce the working principles of basic methods to achieve low temperature by using adiabatic expansion, provide a thorough understanding of applications of classical thermodynamics to different cryogenic technologies, gas separation and purification system, and low power cryocoolers.
2. Understand the structures of different cryogenic systems and the analytical method for cryogenic thermodynamic cycle, and cryogenic gases and liquids and their mixtures

Course Code	**:**	MEOE17
Course Title	**:**	ENERGY CONSERVATION AND MANAGEMENT
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. To learn the present energy scenario and the need for energy conservation

2. To understand the monitoring / targeting aspects of Energy
3. To study the different measures for energy conservation and financial implications of various thermal utilities

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. Guide book 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

Course Outcomes

1. Students will be familiar with Energy Conservation scenario in general and will be mastering the thermal energy auditing technologies / procedures
2. Financial aspects also will be made clear to them as far as Energy Conservation Schemes are concerned. In short, students will become knowledgeable on techno – economic aspects of Energy Conservation

Course Code	**:**	MEOE18
Course Title	**:**	ENERGY STORAGE TECHNOLOGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. To develop the ability to understand / analyse the various types of energy storage.
2. To study the various applications of energy storage systems

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

Reference Books:

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

Course Outcome

Able to anlayse various types of energy storage devices and perform the selection based on techno-economic view point

Course Code	**:**	MEOE19
Course Title	**:**	VECHICLE EMISSIONS AND CONTROL
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**OPEN ELECTIVE**

Course Learning Objectives

1. To introduce effect of air pollution on environment
2. To enable the students to understand the various pollutants.
3. To create confidence to evaluate vehicle pollution levels and measure them.

Course Content

Introduction to pollution, Chemical and thermal dynamics of combustion, Flames and engine combustion.

Atomization and sprays, Engine combustion: SI and CI Engines; Management of engines.

Formation of engine emission, N-O kinetics, Soot formation.

Emission measurement and standards; Control of emissions in SI and CI engines, exhaust after-treatment, NOx catalysts.

Alternative propulsion systems: HEV, FCV etc.; Engine fuel impacts on emissions, alternative fuels e.g., CNG, alcohols, biodiesel, hydrogen, GTL.

Reference Books:

1. J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill International Editions, 1989.
2. B. P. Pundir, Engine Emissions: Pollutant Formation and Advances in Control Technology, Narosa Publishing House, New Delhi, 2007.
3. Handbook of Air Pollution from Internal Combustion Engines: Pollutant Formation and Control, Ed. Eran Sher, Academic Press, 1998.

Course Outcomes

At the end of the course student will
1. Measure the emission based on standards.
2. Apply their understanding on innovative methods to reduce pollution.
3. Interpret ways to control NOx emissions.

c. MINOR (MI)

Course Code	**:**	MEMI10
Course Title	**:**	BASICS THERMODYANMICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. To achieve an understanding of principles of thermodynamics and to be able to use it in accounting for the bulk behavior of the simple physical systems.
2. To provide in-depth study of thermodynamic principles, thermodynamics of state, basic thermodynamic relations, Principle of psychrometry & properties of pure substances
3. To enlighten the basic concepts of vapor power cycles.

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.

Reference Books:

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

At the end of the course student will

1. Analyze any engineering problem based on the basic concepts and logical sequences
2. Define the fundamental laws of thermodynamics and explain their application to a wide range of systems.
3. Analyze the work and heat interactions associated with a prescribed process path and to perform analysis of a flow system.
4. Apply the principle of efficient operation on energy utilization and value its impact on the personal and national economy
5. 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
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. To integrate the concepts, laws and methodologies from the first course in thermo dynamics into analysis of cyclic processes
2. To apply the thermodynamic concepts into various thermal application like IC engines, Steam Turbines, Compressors and Refrigeration and Air conditioning systems

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.

Reference Books:

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

At the end of the course student will

1. Define the basic concepts of units and dimensions, systems(open and closed systems and control volumes) and its boundaries, properties, state, process, cycle, quasi-static process etc.- required as foundation for development of principles and laws of thermodynamics
2. Develop Intuitive problem solving technique
3. Use & Practice two property rule and hence thermodynamic tables, thermodynamic diagrams and concept of equation of state, also their simple application.
4. Explain heat, work and first law of thermodynamics. Application of energy balance

Course Code	**:**	MEMI12
Course Title	**:**	FLUID MECHANICS AND MACHINERY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. The student is introduced to the mechanics of fluids through a thorough understanding of the properties of fluids.
2. The dynamics of fluids is introduced through the control volume approach which gives an integrated understanding of the transport of mass, momentum and energy.
3. The student is introduced with various types of hydraulic machines and its performance.

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.

Reference Books:

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. Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi.

Course Outcomes

At the end of the course student will

1. Understand the properties of fluids and basic principles of fluid mechanics
2. Ability to analyze the fluid flow problems with the application of the mass, momentum and energy equations.
3. Determine flow through hydraulics machines and pipes

Course Code	**:**	MEMI13
Course Title	**:**	FUNDAMENTALS OF HEAT AND MASS TRANSFER
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course objective

1. To learn various modes of heat transfer and understand the basic concepts of mass transfer.
2. To understand the applications of various experimental heat transfer correlations in engineering applications.
3. To discuss the thermal analysis and sizing of heat exchangers.

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

Reference Books:

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

At the end of the course student will

1. Explain about the real time applications of heat transfer in both solids and fluids.
2. Describe the fundamentals of natural and forced convective heat transfer process.
3. Design the heat exchange equipment.
4. Explore the real time applications of radiation mode of heat transfer.

5. Relate the mass transfer concepts for various industrial applications.

Course Code	**:**	MEMI14
Course Title	**:**	MACHINE DESIGN
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. The course will review the concepts of statics and strength of materials used to determine the stress, strain and deflection of one dimensional structures, 2tress in 2D, Plane stress and Strain.
2. Students will learn fundamental approaches to failure prevention for static and repeated loading.
3. Students will be given a thorough understanding of the design of common machine elements such as shafts, fasteners, joints, springs, bearings, and gears.

Course Content

Introduction to Mechanical Design: Design Process; Materials – Properties of Engineering Materials, Selection of Engineering Materials. Load and Stress Analysis – Mohr's Circle

Deflection and Stiffness – Deflection Due to Bending, Deflection Analysis, Compression, Elastic Stability.

Static and Fatigue Failures – Stress Concentration, Failure Theories for Ductile and Brittle Materials, Cyclic Stress, Fatigue Regimes - Combination of Loading Modes

Design of machine elements: Shafts and Shaft Components – Mechanical Springs - Screws, Fasteners and Rivets – Rolling Contact Bearings and Lubrication – Bearing Types, Selection of Bearings

Clutches, Brakes, and Flywheels, Flexible Mechanical Elements

Gears – Types of Gears - Force Analysis, Spur and Helical Gears.

Reference Books:

1. Hamrock, B.J., Schmid, S.R., Jacobson, B., Fundamentals of Machine Elements, McGraw-Hill Higher Education, 2004 - Technology & Engineering
2. Norton, R. L., Machine Design, Prentice Hall, 2014 - Technology & Engineering, 1060 Pages.
3. K. Maekawa, T. Obikawa, Y. Yamane, T.H.C. Childs, Mechanical Design, Elsevier, 04-Dec-2003 - Technology & Engineering - 384 pages.
4. NPTEL :: Mechanical Engineering - Design of Machine Elements I

Course Outcomes

At the end of the course student will

At the end of the course student will be introduced to the stress, strain and deflection of simple mechanical elements and explore the concepts of safety factors of simple structures subjected to static and repeated loads, solve simple and open-ended design problems pertaining to basic machine elements like shafts, bearings, fasteners, springs, clutches, brakes and gears.

Course Code	**:**	MEMI15
Course Title	**:**	FUNDAMENTALS OF AUTOMOTIVE TECHNOLOGY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. To understand the construction and working principle of various parts of an automobile.
2. To have the practice for assembling and dismantling of engine parts and transmission system

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, Bio-diesel 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

Reference Books:

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

At the end of the course student will
1. To develop electronically modified injection systems
2. Identify the use of fuels and its emission characteristics
3. To perform both hydraulic and pneumatic braking systems
4. To identify the type of transmission of motion in vehicles

Course Code	**:**	MEMI17
Course Title	**:**	FUNDAMENTALS OF REFRIGERATION AND AIR CONDITIONING
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. To understand the principles of refrigeration and air conditioning.
2. To design and implement refrigeration and air conditioning systems using standards.

Course Content

Introduction about Refrigeration – Definitions of various terms.

Methods of refrigeration. Air refrigeration system. Bell – Coleman cycle. Introduction about Air craft Air-Conditioning.

Analysis of Vapour compression cycle, Modifications to basic cycle

Psychrometry – Definitions for properties. Introduction to cooling load calculations

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

Reference Books:

1. Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2000
2. Dossat R.D., Principle of Refrigeration, 4th ed., Prentice-Hall, 1997.
3. Manohar Prasad, Refrigeration and Air Conditioning, New Age International, 2004.

Course Outcomes

At the end of the course student will
1. Illustrate the basic concepts of refrigeration system.
2. Explain the components of vapour compression system.
3. Demonstrate the use of psychrometry in analyzing refrigeration systems.
4. Discuss the theory and concept of air-conditioning systems.

Course Code	**:**	MEMI18
Course Title	**:**	PRINCIPLES OF TURBOMACHINERY
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives:

1. To understand the operating principles of various turbomachines and analyse their use for various engineering applications.

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

Reference Books:

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.

Course Outcome

At the end of the course student will able to explain the various systems, principles and applications and different types of turbo machinery components

Course Code	**:**	MEMI19
Course Title	**:**	FUNDAMENTALS OF INTERNALCOMBUSTION ENGINES
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives:

1. To understand the underlying principles of operation in different IC Engines and components.
2. To provide knowledge on pollutant formation, control, alternate fuel etc.

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.

Reference Books:

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

Course Outcome:

At the end of the course student will impart the fundamental knowledge of Internal Combustion Engines

Course Code	**:**	MEMI20
Course Title	**:**	ENGINE POLLUTION AND CONTROL
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. To create an awareness on the various environmental pollution aspects and issues.
2. To give a comprehensive insight into the pollution in engine and gas turbines.
3. To impart knowledge on pollutant formation and control.
4. 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. 100

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

Reference Books:

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.

Course Outcome

At the end of the course student will
1. Learn about pollution formation in engines, and its control
2. The ways and means to protect the environment from various types of pollution

Course Code	**:**	MEMI22
Course Title	**:**	DYNAMICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

By the end of the course, you should be able to do the following:
1. Create mathematical models of dynamic systems (point mass and rigid bodies)
2. Analyze the kinematics of point mass and rigid body systems.
3. Determine the motion of point mass and rigid body systems in space and time.
4. Use engineering software tools such as Mathcad or Mathematica to solve problems of point mass and rigid body systems kinematics and dynamics

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.

Relative Motion

Kinematics of relative motion-Equations of relative motion- D' Alembert's principle in relative motion.

Text Book:

Timoshenko S, and Young D.H, “Engineering Mechanics”, Tata Mcgraw Hill 2006

Course Outcomes

1. Developed a clear understanding of the basic principles that govern the dynamics of particles and rigid bodies and
2. The ability to apply the knowledge and tools to solve engineering problems

Course Code	**:**	MEMI23
Course Title	**:**	FUNDAMENTALS OF MECHANICAL DESIGN
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**MINOR**

Course Learning Objectives

1. Intended to provide an introduction to the design process.

2. Impart the Fundamental information on materials in selecting the most appropriate materials, processes and methods to transform his ideas into a successful product.
3. To understand the effect of various loads and corresponding deformation and stresses in mechanical components.
4. To learn the procedure to design various mechanical components such as shafts, springs, bearing etc.,

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.

Reference Books:

1. Shigley, Mechanical Engineering Design, Ninth Edition in SI Units, Tata McGraw Hill Education Pvt. Ltd., Special Indian Edition, 2011.
2. Robert L. Nortonm Machine Design – An Integrated approach, Pearson Education, 2011
3. U.C. Jindal, Machine Design, Pearson Education India, 2010

Course Outcomes

After the successful completion of this course, a student can

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

IV. ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Course Code	**:**	MELR20
Course Title	**:**	SOM/FM LABORATORY
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives:

1. To study the mechanical properties of materials when subjected to different types of loading.
2. To verify the principles studied in Fluid Mechanics theory by performing experiments in lab.

Course content

Strength of Materials - List of Experiments
1. Tension test on mild steel rod
2. Torsion test on mild steel rod
3. Hardness test on metal beam (Rockwell and Brinell Hardness Tests)
4. Compression test on helical spring
5. Deflection test on carriage spring

Fluid Mechanics - List of Experiments
1. Flow through Venturi meter
2. Characteristics of Centrifugal pumps
3. Characteristics of Gear pump
4. Characteristics of Submersible pump
5. Characteristics of Reciprocating pump
6. Characteristics of Francis turbine
7. Determination of Metacentric height

Course Outcomes:

Upon completion of this course, the students will be able to:
1. Perform Tension, Torsion, Hardness, Compression, and Deformation test on Solid materials.
2. Use the measurement equipments for flow measurement.
3. Perform test on different fluid machinery.

Course Code	**:**	MELR21
Course Title	**:**	MANUFACTURING TECHNOLOGY LABORATORY
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives:

1. To Study and practice the various operations that can be performed in lathe, shaper, drilling, milling machines etc. and to equip with the practical knowledge required in the core industries.
2. To Study and acquire knowledge on various basic machining operations in special purpose machines and its applications in real life manufacture of components in the industry

Course Content

Lathe – Simple / Step / Taper Turning, Thread Cutting, Drilling and Boring.

Shaping – V – Cutting

Milling – Job requiring Indexing.

Hobbing – Spur Gear Cutting

Grinding – Surface / Cylindrical grinding

CNC Lathe – Simple Turing, Step Turning, Thread Turing

Machining Center – A typical job production.

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.

Additive manufacturing/3D printing

Course Outcomes

Upon completion of this course, the students can able
1. To demonstrate and fabricate different types of components using the machine tools
2. To use different machine tools to manufacturing gears.
3. To use different machine tools for finishing operations
4. To manufacture tools using cutter grinder
5. To develop CNC part programming

Course Code	**:**	MELR12
Course Title	**:**	THERMAL ENGINEERING LABORATORY I
Number of Credits	**:**	2
Prerequisites (Course code)	**:**	-NIL-
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives

1. To provide knowledge on testing of properties of fuels and lubricating oils
2. To demonstrate and conduct experiments, interpret and analyze data and report the results of IC Engine testing.

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 fuel 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.

Course Outcomes

At the end of the course student will be able to:
1. Determine the property of fuels and lubricating oils.
2. Evaluate the performance of internal combustion engines and air compressors.
3. Interpret the emission characteristics of internal combustion engines.

Course Code	**:**	MELR17
Course Title	**:**	COMPUTER AIDED DESIGN LABORATORY
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives

1. To introduce the student to the basic tools of computer-aided design (CAD) and computer-aided manufacturing (CAM).
2. To expose the student to contemporary computer design tools for aerospace and mechanical engineers.
3. To prepare the student to be an effective user of a CAD/CAM system.

Course Content

Components drawing with dimensioning
Assembly drawing using modeling software package
Shaft coupling
Bearings
Automobile parts
Machine tool parts

Course Outcomes

At the end of the course student will be able to sketch, construct and simulate the mechanical engineering parts and components which include shaft coupling, bearings, automobile parts, machine tool parts along with their assembly drawing in a CAD package.

Course Code	**:**	MELR22
Course Title	**:**	THERMAL ENGINEERING LABORATORY II
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives

1. To expose the students to the basic knowledge of thermal equipments and help them to develop experimental skills.
2. To study the concepts, applications of the thermal engineering laboratory.

Course Content

Study and performance tests on vapour compression refrigeration.
Study and performance tests on vapour absorption refrigeration.
Study and performance tests on air conditioning test rig.
Heat transfer experiments based on conduction and convection.
Heat transfer experiments based on radiation.
Experiments on heat exchangers.

Course Outcomes

At the end of the course student will
1. Demonstrate conduction, convection and radiation heat transfer through experiments.
2. Interpret heat transfer enhancement mechanisms.
3. Estimate the size and type of heat exchangers.
4. Calculate the cooling load of air conditioning systems and cooling towers.

Course Code	**:**	MELR15
Course Title	**:**	DYNAMICS LABORATORY
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives

1. To equip students with understanding of the fundamental principles of dynamics.
2. To develop a model of a mechanical system using a free body diagram.
3. To develop equations of motion for translational and rotational mechanical systems.

Course Content

Measurement of moment of inertia of rigid bodies.
Gyroscope.
Linear vibration.
Torsional vibration.
Balancing.
Geared system

Course Outcomes

At the end of the course student will
1. Compute the moment of inertia of rigid bodies

2. Demonstrate the working principles of gyroscope.
3. Experiment with vibrations and balancing.

Course Code	**:**	MELR16
Course Title	**:**	AUTOMOBILE ENGINEERING LABORATORY
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives

1. To understand various components of automobile engines.
2. To impart knowledge in the assembling and dismantling of any vehicles and its sub-systems.
3. To Develop students with skills needed for troubleshooting the practical automobile problems

Course Content

1. Study on garage tools and equipments.
2. Experiments on the cleaning & greasing of automobiles.
3. Experiments on the quality of lubrication oil and maintenance.
4. Experiments on the condition of battery quality and maintenance.
5. Experiments on the diagnostic of an Electronic Control Unit (ECU) of an automobile.
6. Dismantling of two / four stroke engine and bring back to the working condition.
7. Dismantling & assembly of Clutch (light / heavy duty vehicle).
8. Dismantling & assembly of Constant mesh gearbox and synchromesh gearbox.
9. Dismantling & assembly of Drive line (universal joint, propeller shaft, slip joint).
10. Dismantling & assembly Final drive & differential.
11. Dismantling & assembly of automatic transmission.
12. Experiments on Wheel balancing and Wheel Rotation.
13. Inspection of Tyre wear pattern and verification of Wheel alignment.
14. Measurement of Exhaust Gas emission and Combustion Analysis.
15. Driving Cycle Analysis using Chassis Dynamometer

Course Outcomes

At the end of the course student will be able to
1. Identify different automotive systems and subsystems
2. Ability to dismantle and assemble engine, transmission, steering, suspension, braking, electrical and electronics systems.
3. Illustrate working and functions of various automotive components

Course Code	**:**	MELR18
Course Title	**:**	METROLOGY AND QUALITY CONTROL LABORATORY
Number of Credits	**:**	2
Prerequisites **(Course code)**	**:**	-NIL-
Course Type	**:**	**ESSENTIAL PROGRAMME LABORATORY REQUIREMENT**

Course Learning Objectives

1. Identify the uncertainties in dimensional metrology and the define the measurement standards; describe the fundamentals of dimensional and geometrical tolerances;
2. Measure length and angles using line-graduated instruments, i. e. vernier callipers, micrometers, bevel protractor, sine bar and surface plates;
3. Use comparative length-measuring instruments, i.e. dial indicator, to measure variations in the distance between two or more surfaces

Course Content

Measurements on precision instruments; sine bar, CMM - Universal measuring microscope, Profile projector - Electronic comparator, optical flat, surface roughness - Gear tooth thickness - MAAG gear tester - Calibration of LVDT - Statistical Quality Control charts.

Course Outcomes

At the end of the course student will
1. Illustrate on different metrological tools and perform measurements in quality impulsion.
2. Describe and explain the working of precision instruments.
3. Outline of electronic comparator, optical flat, surface roughness, gear thickness measuring instruments.
4. Demonstrate the statistical quality control chart.
5. Distinguish with the different instruments that are available for linear, angular, roundness and roughness measurements.
6. Locate appropriate measuring instrument according to a specific requirement.

V. ADVANCED LEVEL COURSES

Course Code	**:**	MEHO10
Course Title	**:**	ADVANCED HEAT TRANSFER
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC22
Course Type	**:**	**HONORS**

Course Objectives

1. To use Heisler and Grober charts and to discuss about transient heat conduction
2. To compare and optimization of longitudinal fin of rectangular, triangular and parabolic profiles
3. To understand boundary layers and to formulate pool and flow boiling correlations
4. To discuss thermal radiation, view factor, gas radiation, radiation effect on temperature measurement.

Syllabus

Transient heat conduction – Exact solution – Use of Heisler and Grober charts–Semi-infinite solids – Multidimensional systems.

Extended surfaces – Steady state analysis and optimization – Longitudinal fin of rectangular, triangular and parabolic profile radiating to free space – Radial fins.

Thermal boundary layers – Momentum and energy equations – Internal and external flows – Forced convection over cylinders, spheres and bank of tubes, turbulent convection.

Heat transfer with phase change – Condensation and boiling heat transfer – Heat transfer in condensation, Effect of non-condensable gases in condensing equipment – Pool and flow boiling correlations.

Thermal radiation – View factor – Gas radiation – Transmitting, reflecting and absorbing media – Flame radiation in furnaces – Radiation effect on temperature measurement.

Course Outcome

At the end of the course student will

1. Discuss about transient heat conduction and to use Heisler and Grober charts
2. Analyze and optimize various fins like rectangular, triangular and parabolic profiles for heat transfer applications.
3. Understand thermal boundary layers, momentum and energy equations
4. Describe condensation and boiling heat transfer and estimate pool and flow boiling heat transfer
5. Analyze thermal and gas radiation in heat transfer equipment.

Reference Books

1. Ozisik, M.N., *Heat Transfer - A Basic Approach*, McGraw-Hill, 1987.
2. Incropera, P.P. and Dewitt, D.P., *Fundamentals of Heat and Mass Transfer*, 5th ed., John Wiley, 2002.

3. Bejan, A., *Heat Transfer*, John Wiley & Sons Inc., 1993.
4. Kakac, S. and Yener, Y., *Convective Heat Transfer*, CRC Press, 1995.
5. Kraus, A.D., Aziz, A., and Welty, J., *Extended Surface Heat Transfer*, John Wiley, 2001.

Course Code	**:**	MEHO11
Course Title	**:**	ADVANCED FLUID MECHANICS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC18
Course Type	**:**	**HONORS**

Course Learning Objectives

1. To familiarize with the properties of fluids and the applications of fluid mechanics.
2. To formulate and analyze problems related to calculation of forces in fluid structure interaction.
3. To classify flows and to understand and apply the conservation principles for fluid flows.
4. To understand the principles of dimensional analysis.

Course Content

Review of Basic concepts- Reynold's transport theorem, Fluid kinematics –

Physical conservation laws - Integral and differential formulations. Navier-Stokes and energy equations - Dimensionless forms and dimensionless numbers - Solution of Navier-Stokes equations.

Two-dimensional Potential flows - Different types of flow patterns, complex potential conformal mapping.

Momentum integral approach. 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 Boundary layer concept.

Boundary layer thickness- Prandtl's equations - Blasius solution-skin friction coefficient.

Reference Books:

1. Currie, LG., Fundamental Mechanics of Fluids, 3rd ed., CRC Press, 2002.
2. White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
3. Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press, 1995.
4. A first course in turbulence, Tennekesse and Lumley
5. Fluid mechanics, Kundu and Cohen

Course Outcomes

At the end of the course student will
1. Identify and obtain the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.
2. Recognize these principles written in form of mathematical equations.

3. Apply dimensional analysis to predict physical parameters that influence the flow in fluid mechanics.

Course Code	**:**	MEHO12
Course Title	**:**	SIMULATION OF IC ENGINES
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**HONORS**

Course Learning Objectives

1. Calculate basic engine parameters of significance for the operation of an engine and the effect of varying them on performance and fuel economy.
2. Simulate engine operation through the use of ideal air cycle models, ideal air exchange models, fuel air processes with chemical equilibrium and time dependent models that include heat transfer and time dependent combustion.
3. Use simple models to describe the combustion processes in spark ignition and diesel engines
4. Evaluate the effect of the air exchange process on engine performance, fuel economy and other basic engine characteristics for 4-stroke engines

Course Content

First and second laws of thermodynamics – Estimation of properties of gas mixtures - Structure of engine models – Open and closed cycle models - Cycle studies

Chemical Reactions, First law application to combustion, Heat of combustion – Adiabatic flame temperature, Chemical Equilibrium and calculation of equilibrium composition - – Heat transfer in engines – Heat transfer models for engines.

Combustion in SI engines, Flame propagation and velocity, Single zone models – Multi zone models – Mass burning rate, Turbulence models – One dimensional models – Chemical kinetics modeling – Multidimensional models.

Combustion in CI engines Single zone models – Premixed-Diffusive models – Wiebe' model – Whitehouse way model, Two zone models - Multizone models- Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model – Introduction to Multidimensional and spray modeling

Thermodynamics of the gas exchange process - Flows in engine manifolds – One dimensional and multidimensional models, Flow around valves and through ports Models for scavenging in two stroke engines – Isothermal and non-isothermal models.

Reference Books:

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.
3. V.Ganesan, Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002.
4. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.

5. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
6. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989.
7. J.N.Mattavi and C.A.Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980.

Course Outcomes

At the end of the course student will
1. Conversant with Basic Concept of Modeling
2. To develop modeling of IC engines.
3. To develop of Laminar Flow modeling
4. Understands Simulation of IC Engines and its new concepts

Course Code	**:**	MEHO13
Course Title	**:**	DESIGN AND ANALYSIS OF TURBOMACHINES
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC21
Course Type	**:**	**HONORS**

Course Learning Objectives

1. Provide students with opportunities to apply basic flow equations;
2. How to compare and chose machines for various operations.

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.

Reference Books:

1. Ganesan, V., Gas Turbines, Tata McGraw-Hill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

Course Outcomes

At the end of the course student will
1. Explain basic concepts of turbomachines and visualize dimensional analysis.
2. Describe the working of Pelton, Francis and Kaplan along their performance parameters.
3. Discuss the operation of centrifugal pumps, centrifugal and axial compressors.
4. Associate the effect of cavitation in turbines and pumps.
5. Express the basic cycles and calculations involved in the operation of steam and gas turbines.

Course Code	**:**	MEHO14
Course Title	**:**	ADVANCED ENGINEERING MATERIALS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC20
Course Type	**:**	**HONORS**

Course Learning Objectives

1. Distinguish various classes of advanced materials, their processing, properties and applications
2. Interpret new terms and information on ultra-light materials, Biomaterials, coatings and thin films, composites, and high temperature refractory materials for aerospace applications.
3. Distinguish materials suitable for application at elevated temperatures and identify coatings suitable for protection applications

Course Content

Ultralight materials and metallic foams, material definition and processing, characterization of cellular metals, material properties

Bio-Materials, classes of materials used in medicine, application of materials in medicine and dentistry, various materials and coatings for implants.
Composite materials, classifications, properties and applications.

Advanced materials - coatings and high- temperature materials

Thin film shape memory alloys for MEMS application

Reference Books:

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.

Course Outcomes

At the end of the course student will
1. Some understanding of types, manufacturing processes, and applications of advanced materials
2. A recognition of the need for and an ability to engage in life-long learning and knowledge of contemporary issues
3. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Course Code	**:**	MEHO15
Course Title	**:**	DESIGN OF HEAT EXCHANGERS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC22
Course Type	**:**	**HONORS**

Course Learning Objectives:

1. To learn the thermal and stress analysis on various parts of the heat exchangers
2. To analyze the sizing and rating of the heat exchangers for various applications

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, U 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.

Reference Books:

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. 2. Sarit Kumar Das, "Process heat transfer", Alpha Science International, 2005
4. John E. Hesselgreaves, "Compact heat exchangers: selection, design, and operation," Elsevier Science Ltd, 2001.
5. Kuppan. T., "Heat exchanger design hand book", New York : Marcel Dekker, 2000.
6. Kays, W.M., and London, A.L., "Compact heat exchangers", Krieger Pub Co., Subsequent edition, 1998.

Course Outcome

At the end of the course student will apply the mathematical knowledge for thermal and stress analysis on various parts of the heat exchangers components

Course Code	**:**	MEHO16
Course Title	**:**	DESIGN AND OPTIMIZATION OF THERMAL ENERGY SYSTEMS
Number of Credits	**:**	3
Prerequisites **(Course code)**	**:**	MEPC16
Course Type	**:**	**HONORS**

Course Learning Objective:

1. To learn basic principles underlying piping, pumping, heat exchangers; modeling and optimization in design of thermal systems.
2. To develop representational modes of real processes and systems.
3. To optimization concerning design of thermal systems.

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-

Reference Books:

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 Outcome:

At the end of the course student will learn the modelling and optimization of thermal system with various equipment like piping, heat exchangers and pumping.